Proceedings of the International Congress of Entomology

FOURTH INTERNATIONAL CONGRESS OF ENTOMOLOGY
ITHACA, AUGUST 1928

VOLUME I

PROCEEDINGS

EDITED BY

K. JORDAN AND W. HORN

ISSUED MARCH 1930

VIII + 83 pages; photograph with key

Communications to be addressed to Dr. K. Jordan,
Zoological Museum, Tring (Herts.), England

PRINTED BY
GOTTFR. PÄTZ, NAUMBURG A/SAALE, WENZELSRING 5.

CONTENTS

FOREWORD

It was originally planned to have the Proceedings and Transactions of the Fourth Congress of Entomology printed in England, the cost of printing in U. S. A. being prohibitive. However, the manuscripts sent in after the Congress were so numerous that, even after the withdrawal or shortening of several of them, the estimated cost was much beyond the funds at our disposal, and we had to accept the lower tender of a continental printer. The firm selected was neither the cheapest nor the dearest of those which offered to undertake the work. It seemed to be the wisest policy to keep expenses fairly within the means available; but we should have learned from Emerson that this saving of money would entail sacrifices in some other direction. Retaliation, indeed, was soon a reality: the printer could not get on with the work as quickly as was arranged with him, proof-reading became a very arduous task, and the plan to bring out the publication at the latest in June or July could not be realized. We are sorry that the members of the Congress have had to wait so long for the issue of the Proceedings and Transactions. The occurrence of such delay is a further argument in favour of the creation of an International Entomological Institute with its own efficient printing office.

The publication of the papers read at the Congress may seem a simple matter: the authors supply the manuscripts, the printer sets them up in type, and the editor hunts for the spelling mistakes which the authors have overlooked in the galley-proof. All might be well indeed, if the manuscripts, *before* being delivered to the editor, had in every case been carefully revised by the author, particularly as to the spelling of *names* and as to punctuation, and if all were in type-script. Authors should bear in mind that compositors, when setting up a manuscript in a language not their own, depend on legibility and on correctness of spelling, and that alterations in the proofs add to the cost of printing. The editor generally bears the blame for printing errors, as he is supposed to reign supreme over author and printer; but as a matter of fact, the compositor can easily knock the conceit out of him by jumbling up a word here and there when attending to some slight corrections in the final revise to which the editor has given his *Imprimatur*.

No attempt has been made at uniformity in spelling and punctuation in the papers contributed by American and English authors; but the senior editor, when going word for word through the galley-proof and revise, may possibly, thru inadvertance, have made slight alterations, for

which he apologizes. On the other hand, English manuscripts sent in by "foreigners" have, as a rule, been revised to some extent before they were handed over to the printer, care being taken, however, not entirely to destroy the individuality of the writings.

There was no uniformity in the manuscripts as to degrees and titles accompanying the names of the authors, and it would appear advisable altogether to omit titles and degrees from the *Transactions* of future Congresses of Entomology.

An appeal for contributions to the printing-fund has been generously responded to by many authors, and the editors take this opportunity of expressing their gratitude.

INTRODUCTION

The Third International Congress of Entomology, Zürich 1925, left the selection of the country for the meeting of the Fourth Congress and the election of the President in the hands of the Executive Committee. The main reason for this action of the Third Congress was the uncertainty as to whether, under the existing general economic depression in Europe, a sufficiently large number of European Entomologists would be able, or be enabled, to bear the expenses of a visit to U. S. A. After some correspondence with Dr. L. O. Howard, the hopeful view prevailed, and it was decided that the Fourth Congress should take place at Ithaca, with Dr. L. O. Howard as its President.

Early in June 1927 the Permanent Secretary of the Executive Committee attended, together with Dr. L. O. Howard, a meeting of members of the local Organization Committee at Cornell, at which meeting ways and means were discussed how to make the Congress a truly International one, and during a stay at the charming Rolling Rock Club in the Alleghenies he placed the matter before Dr. W. J. Holland, who promised to use his wide influence for the furtherance of this deserving international scientific project. And so it came about that the pessimists were put in the wrong: the Carnegie Endowment for International Peace gave a grant of \$5000.— towards the cost of transportation of European Entomologists, and the Organization Committee succeeded in getting support from many sides and to collect a considerable sum of money to pay for the entertainment of the guests from Europe and other foreign countries.*)

The grant of \$5000 was transferred to Europe and spent in acquiring Third Class Tourist Tickets for 25 Entomologists of 17 European countries and 8 single and 17 return tickets New York to Ithaca, and in giving small pecuniary support to a number of other European Congress members who had to bear their own expenses. Two additional British members received a free ticket through the generosity of some British Entomologists who could not themselves attend the Congress. Moreover, various Governments and Institutes appointed and supported delegates, and in the end a larger number of European Entomologists went to Ithaca than had been anticipated in 1927.

---

*) A footnote being generally read even by those who only glance at the text, we wish to draw special attention in this place to the great financial ability of the American Organization Committee as illustrated by the fact that the Treasurer of the Congress could transfer to Europe nearly £670.—.—. as a Publication Fund, a sum considerably in excess of the aggregate fees of members and associates. — Editors.

For the sake of expediency, arrangements were made for the European "Congressists" to travel in two parties, one leaving Southampton via Le Havre on board the Tuscania on 28th July and the other sailing from Rotterdam in the Volendam on 1st August.

A committee of fellows of the Entomological Societies of New York and Brooklyn, headed by Dr. F. E. Lutz, of the American Museum of Natural History, had so well arranged everything as regards the landing formalities that the members of the two parties had no difficulties whatever and were speedily on their way to the hotel or the railroad depot. — It may not be amiss to mention here that visitors to U. S. A. who have a diplomatic visa need not pay the head tax of 8 Dollars.

As the Tuscania party of over 30 passengers arrived in New York on 6th August early in the afternoon and therefore had 4 clear days before going on to Ithaca, the above mentioned Reception Committee had carefully worked out a program of sight-seeing and entertainment. The visits to the Aquarium, the Brooklyn and Staten Island Museums, the Botanical and Zoological Gardens, the whole day excursion by motor coach through the beautiful wooded hills of the Hudson River district to Tuxedo Park, the inspection of the laboratory of Mr. Alfred L. Loomis, the luncheon at the Bear Mountain Inn, the visit to the Boyce Thompson Institute and other Institutes of fame, and the inspection from cellar to attic of the American Museum of Natural History, as well as the generous hospitality offered everywhere to the visitors, were thoroughly appreciated and are very gratefully remembered by all. The special thanks of the visitors are due to Dr. Frank Lutz, who was indefatigable in looking after their comfort and whose energy and circumspection made their stay in New York so very enjoyable and profitable. On Friday, 10 th August, after supper, at which the visitors were the guests of the American Museum of Natural History, they had the privilege of attending at that Institute a joint meeting of the Entomological Societies of Brooklyn and New York. Next morning the members of the party, accompanied by several American colleagues, travelled by the Lehigh Valley railroad to Ithaca, where they arrived in the afternoon and were met by the Organization Committee and despatched to the various hostelries.

The Volendam party, which landed at Hoboken in the evening of 11th August, was conducted from the boat direct to the railroad depot, and, travelling through the night, reached Ithaca early on Sunday morning.

THE CONGRESS

Cornell is an ideal place for a Congress, and the foreign visitors were much impressed by its buildings and the beauty of its situation above Lake Cayuga. The weather being favourable, the organization all that could possibly be desired, and good fellowship an inherent trait of Entomologists, the meetings, excursions and entertainments were most successful. The members and associates, particularly those from foreign countries, are under a great obligation to the Organization Committee, whose careful preparation made the wheels run so smoothly. Space forbids us to give a detailed account of the varied proceedings during the Congress week. But for the sake of pleasurable remembrance and for the guidance of the Organization Committees of future Congresses, as well as in order to create a feeling of regret in those colleagues who were so unfortunate as to be prevented from attending the Congress, we reprint here the information given by the Organization Committee in the introduction to the Program, as to excursions, entertainments, the University and the general physiographical and biological features of the region of the Five Finger Lakes, only those points being left out which no longer apply or are no longer of interest.

General Information.

The Congress is under obligation to Cornell University, the New York State Agricultural Experiment Station at Geneva, individual members of the University and Geneva Experiment Station staffs, many citizens of Ithaca, the Ithaca Chamber of Commerce, the Finger Lakes Association, local officials of transportation companies, railway and steamship officials away from Ithaca, the United States Department of Agriculture, the New York Zoological Society, the University of California, Science Service, the Summer Theater Company, the Finger Lakes Park Commission, the Watkins Chamber of Commerce, Cornell University Athletic Association, Advertising Club of Ithaca and the Louis Agassiz Fuertes Council, Boy Scouts of America. These persons and organizations have done much in order to make the Congress a success. The Carnegie Endowment for International Peace has liberally cooperated in pursuance of its policy to promote international relationships.

Local Arrangements

Registration: Headquarters for the Congress are in Willard Straight Hall. Members are requested to register for excursions and to purchase

tickets at the Excursion Registration Desk as soon as possible after registration. The building will also serve as a place of informal gathering for members of the Congress and their friends. Upon registration members of both classes will be provided with badges bearing their names and addresses, and it is hoped that these will serve as a means of introduction without further formality. All members are requested to wear their badges to all sessions of the Congress. Guides will be available at Willard Straight Hall to assist members to locate places about the campus of the University. Mail, telegrams and other articles for members will be delivered at headquarters.

Lodging and Meals: Members of the Congress and their families may obtain accommodations at headquarters as follows:

Rooms in residence halls of the University, $2.00 per day.

Rooms in private homes near the campus, $1.00 upward per day.

Rooms in hotels in Ithaca on application.

Camping facilities (see below).

Meals will be served during the week of the Congress in the following places:

Cafeteria, Willard Straight Hall, one floor below the registration offices.

Restaurants, Willard Straight Hall, one floor below the main floor at the south end of the building.

Cafeteria, Cascadilla Hall, east entrance, first floor.

Various restaurants adjacent to the campus and in the city.

Arrangements for special luncheons or dinners for groups of members may be arranged by conferring with the Chairman of the Committee on Dinners and Picnics.

Camping Facilities: The University provides camping grounds and facilities east of the stadium on the upper campus. Guides will take campers from headquarters. A guard will remain throughout the week on the camping grounds for the protection of property of campers, but no financial responsibility is assumed. Firewood is provided without cost. Bathing accommodations and toilet facilities for campers are provided through the courtesy of the Cornell University Athletic Association. The College of Agriculture has erected several tents for the use of those who are not fully provided with camping equipment.

Bulletin Service: The attention of members of the Congress is called to the desirability of watching the bulletin board daily in Willard Straight Hall. Any necessary changes in the program or of general plans will be announced there immediately.

Facilities for purchases: Since the shopping district of Ithaca is somewhat removed from the campus of the University, members of the Congress who find it necessary to make purchases should make their desires known at the Information Desk.

Information Regarding Trains: An information desk is maintained at headquarters where time tables can be consulted and information obtained.

Official Photograph: The photograph of the entire Congress will be taken Tuesday at 12:15 p. m., on the north side of the State Drill Hall.

Motion Pictures: Through the courtesy of the United States Department of Agriculture, the New York Zoological Society and the University of California, motion pictures pertaining to insect life, insect control and other subjects of biological interest will be shown in the University Theater in Willard Straight Hall (lower floor). These exhibitions are open without charge to all members of the Congress as well as to younger members of their families.

Afternoon Tea: Each afternoon of the Congress except Tuesday tea will be served to active and associate members of the Congress in Willard Straight Hall from four to six o'clock. As a rule sectional sessions will close in time for members of the Congress partially to utilize this opportunity to meet their fellow entomologists informally.

Smoker, Monday Evening: On Monday evening at eight o'clock, members of the Congress will be the guests of the Department of Entomology of Cornell University at a smoker to be held in Willard Straight Hall.

Plays, Monday Evening: The Summer Theater Company, a student organization, will present five one-act plays in the University Theater on the lowest floor of Willard Straight Hall, Monday evening, August 13, at 9:00 p. m. Tickets are 75 cents each.

Picnic supper, Tuesday Evening, Taughannock Gorge and Falls: The Finger Lakes Park Commission has extended to the Congress the exclusive use of the park at Taughannock for the picnic supper, Tuesday evening, August 14. This park lies 10 miles north of Ithaca on the west shore of Cayuga Lake. Supper will be served at 6:00 p. m. on the shore of the Lake for which a charge of 85 cents is made.

Excursion to Geneva, Wednesday, August 15: The entire Congress will adjourn to the New York State Agricultural Experiment Station at Geneva for all sessions on Wednesday. Arrangements have been made for a special train on the Lehigh Valley Railroad. Lunch will be served on the Station grounds at a moderate charge. The Congress will be the guests of the Experiment Station staff at tea. The New York State Horticultural Society will meet at the Experiment Station at 11:30 a. m. and Thomas B. Byrd of Virginia will address the meeting.

The Banquet, Friday Evening: The last gathering of the entire Congress will be the banquet at 7:00 p. m. in Willard Straight Hall and all active and associate members are urged to attend. The toastmaster will be the President of the Congress, Dr. L. O. Howard. Tickets for the banquet are on sale at headquarters, price $2.00. Formal dress is not expected for the banquet.

Ithaca as a place of interest to entomologists

Ithaca is exceptionally located for a summer meeting of entomologists. It is in the celebrated Finger Lakes Region of Central New York, on the northern border of the Allegheny Plateau. The city proper is located in the deep valley at the head of Cayuga Lake, while the campus of Cornell University is situated on an old lake terrace overlooking the city and lake. Deep gorges intersect the valley sides, two of which bound the campus on the north and south. Three of these gorges within easy reach of

Ithaca have been dedicated as State parks: Enfield Glen, Taughannock Falls and Buttermilk Falls. About twenty-five miles to the west is the noted Watkins Glen at the head of Seneca Lake. The entire region of the Finger Lakes shows a great diversity of topography combined with marked variations in climatic features, providing a wide variety of flora and a consequent diversity of insect fauna. Unexcelled collecting grounds may be found within a few miles of Ithaca with an unusual variety of forms. The geological features and glaciation of this region are responsible for a wide variety of soil conditions so that members of the Congress may collect from fresh water marshes, salt marshes, lake borders, marl springs, peat bogs, ravines, waterfalls, streams of all velocities, upland hills, forests, old pastures and every possible variety on soils of calcareous and non-calcareous nature. Every facility will be provided members of the Congress to visit such places as are indicated either during or following the Congress.

The physiographic history of the Ithaca region is of interest. Cayuga Lake lies in what was apparently a preglacial north-flowing stream valley. The glacier scoured out and greatly deepened this valley. Cayuga Lake, left after the retreat of the glacier, is about 38 miles long, 1-3.5 miles wide and 435 feet deep. the bottom being 52 feet below sea level. The great depth of the lake renders the water comparatively cold in summer and warm in winter. As the ice retreated from the valley after the latter had been greatly deepened by the scouring action of the ice, the tributary streams found themselves high above the valley floor. Their waters in flowing down the steep freshly denuded hillsides immediately began to cut gorges in the rock, and thus the hundreds of ravines of all sizes, for which central New York is noted, were formed. These ravines, therefore, are all of post-glacial origin. Most of these gorges have an eastwest direction since they are tributaries of the north-south lake valley. Their southern walls are protected from the sun, and harbor, besides large numbers of mosses and liverworts, many seed plants of northern range, some of which are rare in New York State and noted among botanists as relics of the northern migration following the retreat of the glacier. On these cool dripping cliffs these plants have escaped extermination, and represent the last stand of a former flora. The north banks of the ravines are sun-baked and support a more southern and more xerophytic flora. Two glacial moraines cross the region near Ithaca. The pockets and dams produced by these moraines contain many peat bogs and marshes of various sizes.

The underlying rocks of the Ithaca region are largely shales and sandstones of Middle and Upper Devonian age. Many of the strata are highly fossiliferous. The strata dip to the southward and the lowest members of the carboniferous formations are found near the Pennsylvania State Line some fifty miles to the south. Limestones of Silurian age outcrop about the north end of Cayuga Lake some 30 miles from Ithaca.

Under the earth at a depth of about 1,000 feet is a somewhat tilted bed of salt which reaches the surface about 50 miles to the north. This has given rise to several salt springs, about which a distinctly salt-loving flora has been developed.

The flora of the Cayuga Basin will be found described in Memoir 92 of the Cornell University Agricultural Experiment Station. The List of the Insects of New York is Memoir 101 and the Lepidoptera of New York is Memoir 68 of the same Station. These may be consulted in Willard Straight Hall. A recent soil map of Tompkins County has been prepared by the Bureau of Soils, United States Department of Agriculture, and the New York State College of Agriculture. This is reprinted in Extension Bulletin 121 of the College of Agriculture, entitled "Soil and Crop Management for Tompkins County, New York." Copies of this Bulletin are available for those desiring such information.

The parks of the finger lakes region

All persons attending the Congress should plan to visit some of the beauty spots of the region, several of which have been dedicated as State Parks. They are within easy reach of Ithaca by automobile. For more complete details consult the booklet issued by the Finger Lakes Association. The following are the more important:

Enfield Glen: Each of the gorges of this region has its individuality, and Enfield will be found different from any other. The deep canyon at the upper entrance terminates shortly in a waterfall 115 feet in height. From the base of the falls to the lower entrance paths lead for about two miles through rich forest, affording excellent opportunities for collecting. The glen has become the retreat of several arctic plants, surviving in the cool recesses since glacial times. Picnic tables, fireplaces and firewood are provided by the Park Commission. The paths through the gorge are safe.

Taughannock Falls and Gorge: The western shore of Cayuga Lake gives no hint of the stupendous canyon of Taughannock. Here are no narrow defiles as at Enfield or Watkins, but the creek has carved for itself since glacial time an ample passage between sheer walls of solid rock that tower hundreds of feet above. At the head of this abyss the waters of Taughannock pour eternally over a leap greater than that of Niagara or of any waterfall east of the Rocky Mountains, yet so unusual are the surrounding cliffs that the falls appear dwarfed when viewed from the rim. The gorge was an unconquerable stronghold of Taughannock, an Algonquin chief, who with his followers never gave allegiance to the Iroquois nations. The gorge offers unique opportunities for collecting, since the south rim and cliffs harbor arctic saxifrages and other northern species of plants which, like Chief Taughannock, have not given way to the invasion of species from the south after the retreat of the glacier. Fireplaces, firewood and picnic facilities are provided by the Finger Lakes Park Commission. The Congress has exclusive use of this park for the picnic supper Tuesday evening, August 14.

Watkins Glen: This noted glen is a post-glacial gorge and is one of the most renowned beauty spots of the eastern United States. It was the site of the aboriginal fortifications of the Algonquin Indians, lying at the head of Seneca Lake. Its interest lies in its majestic scenery and geological formations, but it is less important as a collecting ground for the entomologist than are some other glens. Distance 24 miles. Picnic tables, fireplaces and firewood are provided without charge.

Buttermilk Falls: Lower entrance reached by Cayuga Street. To upper entrance, where Sunday excursion will be run, follow South Aurora Street up steep hill and proceed on Route 15 to first road to right after leaving the city limits. Turn right and then left, following signs to bridge over Buttermilk Creek under construction. From here a path leads to the right following down the post-glacial gorge of the stream, with its many beautiful pot holes and narrow chasms, culminating in Buttermilk Falls. To the left of the bridge are bottom lands and woodlands along the pre-glacial course of the creek, affording excellent collecting grounds. Picnic tables, fireplaces and firewood are provided by the Park Commission at the lower entrance and there is a good swimming pool.

The Cornell Gorges: The campus of the University is bounded on the north and south by deep gorges which are left in their wild state. These are not State Parks, but are the property of the University. Attention is especially called to Ithaca Falls at the base of the gorge of Fall Creek, north of the campus, which can best be observed from the lower road. The Cornell University Athletic Association maintains a swimming pool with attendents in Fall Creek Gorge near the power house. There is a charge of 10 cents.

Wild life preserves

Several tracts are now controlled by Cornell University for the biological work of the various colleges, as follows:

Lloyd-Cornell Reservation at McLean: This is a tract of 81 acres donated by the late Mr. Curtis G. Lloyd of Cincinnati, Ohio. It consists of sphagnum, peat and grass (marl) bogs with surrounding second-growth forest and pastured slopes, rimmed by an esker-like morainal ridge. The locality is a rich one for Trichoptera and other aquatic forms. Among butterflies peculiar to the bogs are: *Amblyscirtes samoset, Carterocephalus palaemon mandan, Pieris virginiensis, Heodes epixanthe, Feniseca tarquinius, Thecla augustus, Melitaea harrisi, Satyrodes canthus, Enodia portlandia.* The carabs *Elaphrus olivaceus, E. clairvillei* and *E. cicatricosus* also occur here. Distance 14 miles.

Lloyd-Cornell Wild Flower Preserve: This is a tract of 420 acres of second growth hardwood forest, adjoining other extensive forested tracts of the hills near Ithaca, also donated by the late Mr. Lloyd as a wild flower preserve. The tract includes a rock-walled gorge in the upper valley of Six Mile Creek. Colonies of *Formica exsectoides*, the mound-building ant of the Allegheny Mountains, made notable by the writings of the late Dr. Henry C. McCook, are to be seen in the open forest of the hill-top. Distance 12 miles.

Lloyd-Cornell Ringwood Wild Life Preserve: This reservation lies 7 miles east of Ithaca, also donated by Mr. Lloyd. This is a tract of 110 acres in the midst of a rolling wooded country at an average elevation of 1600 feet. Kettle holes in the moraine afford ponds, one of which is spring-fed and permanent. To the east of the preserve is a sphagnum bog.

Biological Station and Fuertes Sanctuary: At the head of Cayuga Lake are several units for the study of various branches of biology. The

Louis Agassiz Fuertes Water-Bird Sanctuary, recently established as a memorial, the Cayuga Bird Club Sanctuary for inland birds, the Cornell Biological Station on the marsh and on the hillside, and a fifth tract shortly to be obtained connecting these tracts constitute the complete unit. A museum is to be established in connection with the Fuertes Sanctuary. The building at the Biological Station was destroyed by fire and is not yet rebuilt. An excursion for collecting is planned for Friday afternoon to this area.

Lick Brook and Cayuga Lake Inlet: A collecting trip will be made to this region on Sunday, August 12. This offers a varied environment, such as mud flats, gravel and sand banks along swift flowing streams, some pools of still water, cat-tail marshes, pastured bottom lands with open fields and groves, rank meadow vegetation, upland forest on hill sides and rocky gorge and stream.

Connecticut Hill and Cayuta Lake: A rolling upland region, rising 2100 feet above sea level. The highest point is Connecticut Hill, surrounded by lesser hills, in an extensive area of abandoned farm lands. Forests of hardwoods, pines and hemlock struggle over the slopes and along the upland valleys. Representatives of the Canadian and Upper Austral zone floras mingle here. From Connecticut Hill the land slopes steeply down to Cayuta Lake, about which deep swamps partly timbered offer still other variations in habitat.

Places of interest to forest entomologists

In addition to opportunities for general collecting, the following places may be of special interest:

Arnot Forest: This is a forest area of 1850 acres recently donated for forest research to be conducted by the Department of Forestry of the New York State College of Agriculture by heirs of the late Matthias H. Arnot. Distance 24 miles.

Cornell University Woodlots: These have been managed by the Department of Forestry since 1911 and consist of 79 acres in nine units. Extension bulletin 113 describes these areas and may be obtained on application.

The Department of Forestry also maintains forest plantations, and arrangements may be made to visit any of these desired.

Cornell University

Cornell University was founded in 1865 by Ezra Cornell, a citizen of Ithaca. It now consists of the following Colleges: Arts and Sciences, Engineering, Law, Medicine, Architecture, Agriculture, Home Economics, Veterinary Medicine and the Graduate School. The Colleges of Agriculture, Home Economics and Veterinary Medicine are supported by the State of New York, the others being endowed colleges.

Entomology at Cornell: The teaching of Entomology at Cornell was begun by Professor J. H. Comstock in 1872. The first student to graduate from the University as a specialist in this field was Dr. L. O. Howard, President of the Congress and previously a resident of Ithaca.

The Department of Entomology is part of the New York State College of Agriculture. The offices, laboratories and collections are chiefly located in Roberts Hall. The Entomological Library, including the Comstock Memorial Library, is located in the basement of Stone Hall. The Cornell Beekeeping Library in part of the Library of the College of Agriculture and is in the same room as the entomological library. The insectary is to the rear of Caldwell Hall. The Apiculture laboratory is in the Dairy Building and the apiary is located in a ravine at the head of Beebe Lake. Members of the Congress are invited to make use of these facilities.

The memorial collection of the paintings and other work of the late Louis Agassiz Fuertes are on exhibition in McGraw Hall, second floor.

Insect Collections: The collections are at present housed on the second, third and fourth floors of Roberts Hall. During the Congress the entire collections of certain groups, such as the Membracidae, Cicadidae, etc., will be spread on tables in Roberts 301 and 302 and an exhibit will be made showing museum methods used. The material of every group is, of course, at the disposition of members of the Congress for examination or detailed study before, during and after the Congress. Tables and microscopes will be assigned to all who desire them. The Curators' office is Roberts 406, to which place any persons interested should first go to arrange for viewing or studying any groups. One of the curators will be at the office daily.

The insect collections of Cornell University occupy over 3,000 cases, 19 x 16 inches. Without having counted one may roughly estimate that they consist of somewhere between one and two million specimens. There is no count of the number of species represented in each order, but the relative size of the collection of each may be approximated from the number of cases devoted to it: Lepidoptera 800, Hymenoptera 580, Coleoptera 520, Diptera 300, Hemiptera 280, Odonata 170, Orthoptera 70, Neuroptera 50, Neuropteroid, etc., 40, Trichoptera 25. The above estimates do not include the collection of Arachnida, which must rank as one of the two or three most extensive in this country. It is contained in what is estimated to be between 20,000 and 25,000 vials. The collection is not limited to any geographical area, but particular emphasis is naturally laid upon the acquisition of the fauna primarily of New York State and secondarily of North America.

Outside of New York State material, besides innumerable lesser accessions from all parts of the world, one may especially mention the following as sources of material, each probably upwards of 25,000 specimens: Cornell University Entomological Expedition to South America of 1919-20 (100,000-200,000 specimens); Okefinokee Expedition of 1912-13, and other Georgia and Florida material collected by J. C. Bradley during several years; British Columbia and Alberta material from J. C. Bradley, 1905-1908; California material from J. C. Bradley, 1906-07, 1914, 1915, 1917-19; Southern and Southwestern material from Cornell Biological Expedition of 1919; Heidemann collection of Hemiptera; R. J. Crew collection of Coleoptera. Of lesser extent may be mentioned the Murtfeldt collection of Microlepidoptera, Sherman collection of Carabidae (640 spp.)

and extensive series of Hymenoptera from the Naturhistorische Museum of Vienna, 667 species of French spiders from the Simon collection, about 1,200 species of exotic Hemiptera (purchased), 730 species of North American Lepidoptera and Hemiptera from all regions from the Baker collection, collections of Chilean insects, chiefly Hymenoptera, from Alfredo Faz and from the Museo de Historia Natural of Santiago, of Argentinian from Carlos Road, of Urguayan insects from the Museo de Historia Natural de Montevideo, South America Hemiptera and Hymenoptera from H. L. Parish, East African Hymenoptera from H. Junod, an extensive Brazilean collection in all orders from A. G. Hammar, the sawfly collection accumulated previous to 1911 by the late A. D. MacGillivray, several thousand species of European insects of several orders purchased from time to time of Schmiedeknecht, Konow, and from dealers, There have recently been added about 250 determined and many undetermined Ithomiidae and Danaidae representing the personal collection of Fassl. Types of about 1,000 species have been catalogued, but the work is not yet completed.

Insectary: This building is located to the rear of Caldwell Hall on the Agricultural campus and is used for the rearing and study of economic insects. The building will remain open during the week of the Congress and there will be some person at hand.

The Experiment Stations: The State of New York maintains two agricultural experiment stations, one at Ithaca in connection with the New York State College of Agriculture and the other at Geneva. The two stations are under the same administartion. The grounds of the Cornell University Experiment Station are an extension of the farm donated to the University by its founder and now consists of about 1300 acres. Members of the Congress who are interested in visiting any special features on the Station grounds should make their desires known to headquarters and arrangements will be made.

The Physiological Experiment Station of the Department of Medicine for the study of thyroid secretions is located on Cayuga Heights about two miles north of the campus. The College of Veterinary Medicine maintains an experimental farm about two miles east of the campus. The fish culture station is beyond the East Ithaca Station of the Lehigh Valley Railroad. The poultry farms are about two miles northeast of the campus. The astronomical observatory of the University is on the north shore of Beebe Lake.

Excursions

Sunday, August 12

9:00 a. m. Buttermilk Creek, upper entrance to gorge, visit to gorge, and collecting trip.
Leave Willard Straight Hall; leader, A. B. Klots.

1:30 p. m. Lick Brook and Valley of Cayuga Lake Inlet collecting trip.
Leave Willard Straight Hall: leader, F. C. Fletcher. Return by 7:00 p. m. Rough clothing advisable.

Monday, August 13

3:00 p. m. Enfield Gorge. Leave Willard Straight Hall: leader, Professor W. C. Muenscher, Department of Botany, returning by 6:30 p. m. A walk of about two miles from the upper to the lower entrance of the Park. Registration for this excursion must be made by noon on Monday. See also excursion for Saturday afternoon to Enfield Gorge.

4:00 p. m. Walk through Fall Creek Gorge on the campus. First party leaves Willard Straight Hall: leader, P. P. Kellogg.

5:00 p. m. Second party for Fall Creek Gorge: leader, A. B. Klots. No registration necessary.

Tuesday, August 14

4:00 to 4:30 p. m. Picnic supper Taughannock Falls State Park. Automobiles will leave from the front of *Bailey Hall*, Professor Robert Matheson in charge. Picnic supper will be served on the shore of Cayuga Lake at *6:00 p. m.* On arrival, a walk of about a half mile will be taken up the gorge to the falls. Tickets for the picnic supper are 85 cents.

Wednesday, August 15

The Congress meets at the New York State Agricultural Experiment Station at Geneva, New York. There will be no activities of interest to entomologists in Ithaca on this day. (See Entertainment for Visiting Women on Wednesday, page 33).

11:30 a. m. Meeting of the New York State Horticultural Society.

5:00 p. m. Tea.

7:30 p. m. Return to Ithaca.

Thursday, August 16

8;30 a. m. The Lloyd-Cornell Wild Flower Preserve, collecting trip. Leave Willard Straight Hall, Professor J. Chester Bradley in charge, returning by 1:00 p. m. Rough clothing advisable.

9:00 a. m. Arnot Forest. Section of Forest Entomology. Leave Willard Straight Hall, Professor J. N. Spaeth, Department of Forestry, in charge. Return in time for lunch.

4:00 p. m. University Fish Hatchery, for collecting aquatic insects. First party leaves Willard Straight Hall on foot under the leadership of Professor George C. Embody. This is a walk of one mile each way.

5;00 p. m. University Fish Hatchery. Second party leaves Willard Straight Hall by automobiles under the leadership of Dr. Paul R. Needham.

6:30 p. m. Picnic supper for the Section on Apiculture on the shore of Beebe Lake, Mrs. Everett Oertel in charge. Registration at the Tuesday meeting of this Section.

8:30 p. m. Lick Brook for sugaring and collecting at light. Leave Willard Straight Hall: leaders, F. C. Fletcher and A. B. Klots.

Friday, August 17

8:30 a. m. Lloyd-Cornell Ringwood Wild Life Preserve and the Lloyd-Cornell Wild Flower Preserve. Leave Willard Straight Hall, returning in time for lunch. Leader, W. C. Senning. Rough clothing advisable. A brief visit to the Wild Flower Preserve will be made on the return trip.

3:30 p. m. Six Mile Creek. Walking trip (3.5 miles) for collecting. Leave Willard Straight Hall under the leadership of A. B. Klots, returning by 6:00 p. m. No registration necessary.

3:30 p. m. Cornell Biological Station at Renwick, for collecting aquatic insects. Leave Willard Straight Hall under the leadership of Dr. Paul R. Needham, going on foot (one mile) and returning by electric car by *6:00 p. m.*

Saturday, August 18

8:30 a. m. Lloyd-Cornell Reservation at McLean. Leave Willard Straight Hall, returning by *12:30 p. m.* Leader, Dr. C. K. Sibley.

2:00 p. m. Enfield Falls and Watkins Glen. Leave from front of *Bailey Hall* under the direction of Professor P. W. Claassen. Supper at Watkins, *6:30 p. m.*, returning about *8:00 p. m.*

A short stop will be made at Enfield upper entrance to visit the Upper Gorge and Falls. There will be opportunity for a walk through the Glen at Watkins, after which supper will be obtained. Restaurants are available near the entrance to the Glen, but it is preferable to obtain a box lunch in advance at Willard Straight Hall cafeteria.

2:00 p. m. Michigan Hollow, for those who prefer to spend the afternoon collecting rather than to go to Watkins. Leave Willard Straight Hall under the leadership of F. C. Fletcher, returning by *6:30 p. m.* Michigan Hollow is a richly wooded section and a favorite collecting ground.

Sunday, August 19

8:39 a. m., leave Lehigh Valley depot, arriving at Niagara Falls *2:02 p. m.* Returning leave Niagara Falls at *5:58 p. m.*, arriving at Ithaca *12:00* midnight. There will be time for luncheon at Buffalo on the going trip and for evening dinner on the return trip. Electric cars making the trip down the Canadian side of the gorge, returning via the American side, leave Niagara Falls Terminal Station every half hour. Fare $1.50; time 1 hour 55 minutes. Fare $7.40 for the round trip or $5.69 one way,

The Excursion to Chief Entomological Centers is a continuation of the Niagara Falls excursion.

8:30 a. m. Connecticut Hill State Game Refuge and Cayuta Lake. Leave Willard Straight Hall, returning in time for supper under the leadership of A. B. Klots. An Imu dinner will be prepared for those attending by the Boy Scouts of Ithaca under the direction of Professor E. L. Palmer, at a charge of 50 cents.

Monday, August 20

10:00 a. m. Summer Meeting and Picnic of the Empire State Federation of Beekeepers' Societies and the Finger Lakes Beekeepers' Association at the home and apiary of Mr. E. L. Lane, Trumansburg, for the Section on Apiculture. Leave Willard Straight Hall under the leadership of Professor E. F. Phillips. A place is provided for obtaining lunch at the grounds. Return in time for evening dinner.

Adirondack Mountains Excursion for the Section of Forest Entomology. A three or four days trip to the Adirondack Mountains region of northern New York will be arranged for a small group if desired. This will be in charge of the New York State Conservation Commission.

Tuesday and Wednesday, August 21 and 22.

Visits to commercial apiaries and summer meeting of the Western New York Honey Producers' Association. Leave Willard Straight Hall Tuesday morning at *9:00 a. m.*, to visit apiaries lying in the transition region of central New York and in the drumlin region on the way to Batavia. Remain all night at Batavia and proceed Wednesday morning to the apiary of Mr. James H. Sprout, Akron Road, Lockport, where the picnic will be held. Return may be made to Ithaca that evening, or those going westward may proceed from Lockport over main highways.

Excursion to Chief Entomological Centers:

Monday, August 20

PITTSBURGH: Visit Carnegie Museum, park and conservatory and the Carnegie Institution. The party will be guests of Dr. W. J. Holland at dinner (*7:00 p. m.*) at the University Club.

Tuesday, August 21, to Friday, August 24

WASHINGTON: Program will include the United States National Museum, the Bureau of Entomology, the Biological Survey, an afternoon at Plummer Island and other points of interest.

Saturday, August 25, to Monday, August 27

PHILADELPHIA: Program will include the Academy of Natural Sciences, the American Entomological Society, a field excursion to the New Jersey Pine Barrens for collecting in a typical Austral (Carolinian) faunal area, the Japanese Beetle Laboratory at Moorestown, New Jersey, a visit to the Du Pont Gardens at Kennett Square, the University of Pennsylvania, Wistar Institute of Anatomy and other points of interest.

Tuesday, August 28, and Wesnesday, August 29

BOSTON: The program will include visits to the Museum of Comparative Zoology, Harvard University, Cambridge, the Bussey Institution, Forest Hills, the Boston Society of Natural History, the Gypsy Moth Laboratory, Melrose Highlands and the Corn Borer Laboratory Arlington.

Friday, August 31

NEW YORK: Visits to the American Museum of Natural History, the Brooklyn Museum, the Museum of the Staten Island Institute of Arts and Sciences, the Museum of the American Indian, the Aquarium, and the Botanical and Zoological Gardens in the Bronx.

Entertainment for women

Registration for the special events for visiting women is to be made at the *Excursion Registration Desk* at headquarters. Women are of course welcome to go on all Excursions in connection with the Congress.

Sunday, August 12

4:00 p. m. Tea, Willard Straight Hall, Mesdames J. H. Comstock and J. G. Needham hostesses.

8:00 p. m. Informal gathering for all members of the Congress, Willard Straight Hall.

Monday, August 13

3:00 p. m. Excursion, Enfield Glen. Mrs. Everett Oertel will be in charge of the party of women. Leave Willard Straight Hall.

4:00 p. m. Excursion, Fall Creek Gorge. Mrs. P. J. Chapman will conduct a party of women. Leave Willard Straight Hall.

4:00 p. m. Tea, Willard Straight Hall, Mrs. O. A. Johannsen hostess.

7:30 p. m. Smoker, Willard Straight Hall, to which women are invited.

9:00 p. m. Summer Theatre Plays, University Theatre, Willard Straight Hall.

Tuesday, August 14

10:00 a. m. Tour of the University campus by automobile. Leave Willard Straight Hall, Mrs. P. R. Needham in charge.

4:00-4:30 p. m. Leave *Bailey Hall* for picnic supper at Taughannock Falls. Tea will not be served Tuesday afternoon.

Wednesday, August 15

9:00 a. m. Special train to Geneva for meetings of Congress.

4:00 p. m. Tea, Willard Straight Hall, Mrs. Robert Matheson hostess.

Thursday, August 16

10:00 a. m. Visit to College of Home Economics where visitors will be received by members of the Faculty. Leave Willard Straight Hall, Mrs. Robert Matheson in charge.

10:00 a. m. Visit to the University Library where visitors will be directed through the stacks and will be shown the special collections by Librarian Willard Austen. Leave Willard Straight Hall, Mrs. Robert Matheson in charge.

1:00 p. m. Invitation Luncheon, Willard Straight Hall, Dining Room D, given to visiting women actively engaged in entomological work by the Sigma Delta Epsilon, Graduate Women's Scientific Fraternity.

2:30 p. m. Bridge Party, Willard Straight Hall, Mrs. E. F. Phillips in charge.

4:00 p. m. Tea, Willard Straight Hall, Mrs. Glenn W. Herrick hostess.
7:30 p. m. Singing on steps of Goldwin Smith Hall.

Friday, August 17

For the two trips on Friday morning, women desiring to go on either one will please register before Wednesday evening.

9:30 a. m. Visit to Ithaca shops, Mrs. Cornelius Betten in charge. Leave Willard Straight Hall.

9:30 a. m. Visit to various social centers in Ithaca and to Reconstruction Home (for victims of infantile paralysis). Leave Willard Straight Hall, Mrs. B. A. Slocum in charge.

4:00 p. m. Tea, Willard Straight Hall, Mrs. C. R. Crosby hostess.
7:00 p. m. Banquet to which all active and associate members are invited.

Saturday, August 18

10:00 a. m. Drive through Ithaca and environs. Leare Willard Straight Hall. Mesdames P. W. Claassen and E. F. Phillips in charge.

2:00 p. m. Excursion, Enfield-Watkins.
4:00 p. m. Tea, Willard Straight Hall, Mrs P. W. Claassen hostess.

Sunday, August 19

8:30 a. m. Excursion, Connecticut Hill.
8:39 a. m. Excursion, Niagara Falls.
4:00 p. m. Tea, Willard Straight Hall, Mesdames J. H. Comstock and J. G. Needham hostesses.

Officers of the Congress

PRESIDENT

Leland Ossian Howard, Ph. D., M. D., LL. D., D. Sc., Bureau of Entomology, Washington, D. C.

VICE-PRESIDENTS

William Morton Wheeler, Ph. D., D. Sc., Professor of Entomology, Bussey Institution, Harvard University, Forest Hills, Massachusetts

James George Needham, Ph. D., Litt. D., Professor of Entomology and Limnology, New York State College of Agriculture, Cornell University, Ithaca, New York

GENERAL SECRETARY, FOURTH INTERNATIONAL CONGRESS OF ENTOMOLOGY

Professor O. A. Johannsen, New York State College of Agriculture, Cornell University, Ithaca, New York, U. S. A.

TREASURER OF THE FOURTH INTERNATIONAL CONGRESS OF ENTOMOLOGY

Professor C. R. Crosby, New York State College of Agriculture, Cornell University, Ithaca, New York

EXECUTIVE COMMITTEE OF THE INTERNATIONAL CONGRESSES OF ENTOMOLOGY

Dr. Karl Jordan, Zoological Museum, Tring, Herts., England, *Permanent Secretary*

Dr. Walther Horn, Deutsches Entomologisches Institut, Berlin-Dahlem, Deutschland

Dr. Harry Eltringham. University Museum, Oxford, England

Dr. Yngve Sjöstedt, Naturhistoriska Riksmuseets, K. Vetenskapsakademien, Stockholm, Sverige

Dr. René Jeannel, Directeur du Vivarium, Muséum National d'Histoire Naturelle, Paris, France

Dr. O. A. Johannsen, Cornell University, Ithaca, New York, U. S. A.: cf. p.

American Organization Committee

HONORARY MEMBERS

Professor John Henry Comstock, Cornell University, Ithaca, New York

Professor S. A. Forbes, University of Illinois, Urbana, Illinois

Dr. Eugene Amandus Schwarz, United States National Museum, Washington, D. C.

REPRESENTING THE ENTOMOLOGICAL SOCIETY OF AMERICA

Dr. Elmer D. Ball, State Plant Board, Sanford, Florida
Professor Philip P. Calvert, University of Pennsylvania, Philadelphia, Pennsylvania
Dr. Frank E. Lutz, American Museum of Natural History, New York City

REPRESENTING THE AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

Dr. William J. Holland, Carnegie Museum, Pittsburgh, Pennsylvania
Dr. Leland O. Howard, Bureau of Entomology, Washington, D. C.
Professor James G. Needham, New York State College of Agriculture, Cornell University, Ithaca, New York
Professor Herbert Osborn, Ohio State University, Columbus, Ohio

REPRESENTING THE ENTOMOLOGICAL SOCIETY OF ONTARIO, DOMINION OF CANADA

Professor A. W. Baker, Ontario Agricultural College, Guelph, Ontario
Professor W. H. Brittain, Macdonald College, Quebec
Arthur Gibson, Dominion Entomologist, Ottawa, Ontario

MEMBERS OF THE LOCAL COMMITTEE, *ex officio*

Chairman, Professor James G. Needham, New York State College of Agriculture, Cornell University, Ithaca, New York

AMERICAN EXECUTIVE SECRETARY

Professor O. A. Johannsen, New York State College of Agriculture, Cornell University, Ithaca, New York

General Committee on Local Arrangements

Professor James G. Needham, Chairman
Professor Glenn W. Herrick, Vice-chairman
Professor P. J. Parrott, Vice-chairman
Professor C. R. Crosby, Treasurer
Professor E. F. Phillips, Chairman, Committee on Program
Professor P. W. Claassen, Chairman, Committee on Local Entertainment
Professor O. A. Johannsen, Local Secretary
Secretaries of all sections and sub-sections

Organizing Secretaries of Sessions

Systematic Entomology and Zoogeography, Professor J. Chester Bradley
Nomenclature and Bibliography, Dr. P. P. Babiy
Morphology, Physiology, Embryology and Genetics, Professor O. A. Johannsen and Dr. W. T. M. Forbes
Ecology, Professors James G. Needham and P. W. Claassen
Medical and Veterinary Entomology, Professor Robert Matheson
Apiculture, Professor E. F. Phillips
Forest Entomology, Professor Glenn W. Herrick

Economic Entomology:

Citrus Fruit Insects, Professor P. J. Parrott

Desiduous Fruit Insects, Professor P. J. Parrott

Cereal and Truck Crop Insects, Professor C. R. Crosby and Dr. P. J. Chapman

Cotton Insects, Dr. J. W. Folsom, Cotton Boll Weevil Laboratory, Tallulah, Louisiana

Insecticides and Appliances, Professor Hugh Glasgow

Committee on Local Entertainment

Chairman	Prof. P. W. Claassen
Smoker	Prof. C. R. Crosby
Exhibits and apparatus	M. A. Stewart
Entertainment of visiting women	Mrs. A. B. Comstock and Mrs. J. G. Needham
Registration and room assignment	Dr. Cornelius Betten and Donald T. Ries
Automobile transportation	Dr. P. R. Needham
Excursions	Prof. J. Chester Bradley
Dinners and picnics	Prof. Robert Matheson
Reception and personal service	Prof. J. G. Needham
Floral decorations	Dr. Grace Griswold
Information service and guides	L. E. Wolf
Photographs	Myron Gordon
Outdoor sports	W. J. Hamilton, Jr.
Camping supervision	P. D. Harwood
Interpreting service	Dr. P. P. Babiy
Stenographic help	Katherine Warren
Railroad transportation	Prof. J. Chester Bradley
Bulletin board service	B. A. Slocum
Insectary	Dr. L. P. Wehrle
Assistance for collecting	F. C. Fletcher
Police assistance	Captain C. G. Mead

Patrons

American Association of Economic Entomologists (Secretary, Melrose Highlands, Massachusetts)
American Entomological Society, Philadelphia, Pennsylvania
Brooklyn Entomological Society, Brooklyn, New York
Cambridge Entomological Club, Cambridge, Massachusetts
Carnegie Endowment for International Peace, New York City
Professor and Mrs. J. H. Comstock, Ithaca, New York
The Congress of the United States, Washington, D. C.
Cornell University, Ithaca, New York
Entomological Society of America (Secretary, Lafayette, Indiana)
Entomological Society of Ontario, (Secretary, Guelph, Ontario)
The Jugatae, New York State College of Agriculture, Ithaca, New York
New York Entomological Society, New York City
New York State Agricultural Experiment Station Geneva, New York
New York State College of Agriculture, Cornell University, Ithaca, New York
Washington Entomological Society, Washington, D. C.

Honorary Members

1. Professor I. Bolivar, Museo de Ciencias Naturales, Hipódromo, Madrid, Spain.
2. Professor E. Bugnion, Aix-en-Provence, France.
3. Professor J. H. Comstock, Cornell University, Ithaca, N. Y., U. S. A.
4. Dr. J. Escher-Kündig, Gotthardstrasse 35, Zürich, Switzerland.
5. Dr. E. Everts, Emmastraat 28, The Hague, Holland.
6. Professor S. A. Forbes, Urbana, Illinois, U. S. A.
7. Dr. A. Forel, La Fourmilière, Yvorne, Vaud, Switzerland.
8. Dr. R. Gestro, Museo Civico, Genova, Italy.
9. Hofrat A. Handlirsch, Rubensgasse 5, Wien, Austria.
10. Dr. W. J. Holland, Carnegie Museum, Pittsburgh, Penna., U. S. A.
11. Dr. G. Horváth, Nemzeti Museum, Budapest, Hungary.
12. Dr. Ch. Janet, Voisinlieu, France.
13. Professor S. Matsumura, Sapporo, Nippon.
14. Professor E. B. Poulton, University Museum, Oxford, England.
15. A. Semenov-Tjan-Shansky, Academy of Sciences, Leningrad, U. S. S. R.

Members and Associates

Names of members and associates who attended the Congress are printed in *italics.* *) * = life-members.

1. Academia de Ciencias Exactas, Fisico Quimicas y Naturales de Zaragoza, Zaragoza, Spain.
2. *Adams,* Director C. C., New York State Museum, Albany, N. Y., U. S. A.
3. *Adams,* Director C. F., State Laboratory, Indiana State Board of Health, Indianapolis, Ind., U. S. A.
4. Adkin, Robert, Hodeslea, Eastbourne, England.
5. *Adrianov,* A. P., Agricultural Commissariat, Moscow, 34, Glasovski Str. 3, Room 7, U. S. S. R.
6. Agricultural Research Institute, Pusa, British India.

*7. Akermann, C., c/o Messrs. Morcom & Co., Court Gardens, Pietermaritzburg, Natal, South Africa.

8. *Aldrich,* J. M., Associate Curator, Division of Insects, U. S. National Museum, Washington, D. C., U. S. A
9. *Aldrich,* Mrs. J. M. (Associate).
10. *Alexander,* Professor C. P , Massachusetts Agricultural College, Amherst, Mass., U. S. A.
11. *Alexander,* Mrs. C. P. (Associate).
12. *Allen,* Professor A. A., Cornell University, Ithaca, N. Y., U. S. A.
13. *Allen,* H. W., Japanese Beetle Laboratory, U. S. Bureau of Entomology, Moorestown, N. J., U. S. A.
14. *Alpatov,* W. W., University of Moscow. U. S. S. R., Fellow of the International Education Board, Johns Hopkins University, Baltimore, Md., U. S. A.
15. American Entomological Society, Academy of Natural Sciences, Logan Square, Philadelphia, Penna, U. S. A.
16. *Anderson,* E. J., Pennsylvania State College, State College, Pa., U. S. A.
17. *Argo,* V. N., Ohio State University, Columbus, Ohio, U. S. A.
18. *Argo,* Mrs. V. N. (Associate)
19. *Assmuth,* Professor J., Fordham University, New York, N. Y., U. S. A.
20. *Avinoff,* Director A., Carnegie Museum, Pittsburgh, Pa., U. S. A.
21. *Axlerod,* A., University of Buffalo, Buffalo, N. Y., U. S. A.
22. *Babiy,* P. P., Curator of Invertebrate Zoology, New York State College of Agriculture, Ithaca, N. Y., U. S. A
23. *Babiy,* Mrs. P. P. (Associate).
24. *Back,* E. A., U. S. Bureau of Entomology, Washington, D. C., U. S. A.
25. *Baerg,* Professor W. J., University of Arkansas, Fayetteville, Ark., U. S. A.
26. *Baird,* A. B., Department of Agriculture, Ottawa, Canada.
27. *Baker,* A. C., U. S. Bureau of Entomology, Washington, D. C., U. S. A.
28. *Baker,* Mrs. A. C. (Associate).
29. *Baker,* Professor A. W., Ontario Agricultural College, Guelph, Ontario, Canada.

---

*) As none of the members registered at the Congress as "Dr.", this title has been omitted throughout this list.

30. *Balduf,* Professor W. V., University of Illinois, Urbana, Ill., U. S. A.
31. *Ball,* A. F., Aide-Naturaliste, Musée Royal d'Histoire Naturelle, 31 rue Vautier, Bruxelles, Belgium.
32. *Ball,* Director E. D., Agricultural Experiment Station, Tucson, Ariz., U. S. A.
33. *Ballou,* C. H., Japanese Beetle Laboratory, U. S. Bureau of Entomology, Moorestown, N. J., U. S. A.
34. *Ballou,* Mrs. C. H. (Associate).
35. Ballou, H. A., Imperial College of Tropical Agriculture, Trinidad, West Indies.
36. *Balzer,* A. I., U. S. Department of Agriculture, Monroe, Mich., U. S. A.
37. *Bare,* C. O., U. S. Bureau of Entomology, Sanford, Fla., U. S. A.
38. *Barnes,* P. T, 908 Highland Ave., Palmyra, N. Y., U. S. A.
39. *Barnes,* T. C., Trinity College, Cambridge, England.
40. Barns, Principal W., College of Agriculture, Poona, South India.
41. *Baunacke,* Professor K. W., Abteilungsvorstand, Abteilung Pflanzenschutz der Staatl. Landwirtschaftl. Versuchsanstalt, Dresden A 16, Germany.
42. *Bayonnet,* V., 212 Short St., Butler, Pa., U. S. A.
43. *Benjamin,* F. H., U. S. Department of Agriculture, Brownsville, Texas, U. S. A.
44. *Benjamin,* Mrs. F. H. (Associate).
45. *Bentley,* Professor G. M., University of Tennessee, Knoxville, Tenn., U. S. A.
46. *Benton,* C., U. S. Bureau of Entomology, West Lafayette, Ind., U. S. A.
47. *Bequaert,* Professor J. C., Harvard University Medical School, Boston, Mass., U. S. A.
48. *Bertholf,* Professor L. M., Western Maryland College, Westminster, Md., U. S. A.
49. *Bertholf,* Mrs. L. M. (Associate).
50. *Betten,* Director C., New York State College of Agriculture, Ithaca, N. Y., U. S. A.
51. *Betten,* Mrs. C. (Associate).
*52. Bibliothèque du Ministère de l'Agriculture, Bruxelles, Belgium.
*53. Bibliothèque du Ministère des Colonies, Bruxelles, Belgium.
*54. Biedermann, R., Villa Sonnenberg, Winterthur, Switzerland.
55. *Bhosale,* Y., Dewas Junior, Central India.
56. *Bilsing,* Professor S. W., A. & M. College of Texas, College Station, Texas, U. S. A.
57. *Bird,* H., Rye, N. Y., U. S. A.
58. *Bishop,* Professor G. H., Washington University Medical College, St. Louis, Mo., U. S. A.
59. *Bishopp,* F. C., U. S. Bureau of Entomology, Washington, D. C., U. S. A.
60. *Bisset,* G. B., The Moorings, Peterhead, Aberdeenshire, Gt. Britain.
61. *Blackman,* Professor M. W., New York State College of Forestry, Syracuse, N. Y., U. S. A.
62. *Blaisdell,* Professor F. E., Stanford Medical School, Lane Medical Library Building, San Francisco, Cal., U. S. A.
63. *Blaisdell,* Mrs. F. E. (Associate).

64. *Blatchley*, W. S., 1530 Park Ave., Indianapolis, Ind., U.S.A.
65. *Bledowski*, Professor R., Free University of Poland, Warsaw, Poland.
*66. Board of the Carnegie Institute, Pittsburgh, Penna, U.S.A.
67. Bodenheimer, Professor F., Hebrew University, P. O. Box 340, Jerusalem, Palestine.
68. *Bodine*, Professor J. H., University of Pennsylvania, Philadelphia, Penna., U.S.A.
69. *Bogdanov-Katjkov*, Professor N. F., Director, Northern Plant Protection Station, Leningrad, U.S.S.R.
70. *Bolivar*, Professor C., Madrid University, Museo Ciencias Naturales, Madrid, Spain.
71. *Bollini*, A. T., Consul General of Argentine Republic, Argentine Consulate, 17 Battery Place, New York City, N.Y., U. S. A.
72. *Bollini*, Mrs. A. T. (Associate).
73. *Borodin*, D. N., 622 W. 114th St., Apt. 34, New York City, N. Y., U.S.A.
74. *Bostwick*, C. D., Comptroller of Cornell University, Ithaca, N. Y., U. S. A. (Associate.)
75. *Bourne*, Professor A. I., Massachusetts Agricultural Experiment Station, Amherst, Mass., U.S.A.
76. *Bouvier*, Professor E.-L., Muséum d'Histoire Naturelle, Paris, France.
77. *Böving*, A. G., U.S. Bureau of Entomology, Washington, D. C., U.S.A.
78. *Boyce*, Director J. S., Northeastern Forest Experiment Station, U.S. Forest Service, Amherst, Mass., U.S.A.
79. *Bradley*, Professor J. C., New York State College of Agriculture, Ithaca, N.Y., U.S.A.
80. *Brittain*, Professor W. H., McGill University, Macdonald College, Quebec, Canada.
81. *Britton*, W. E., State Entomologist, Connecticut Agricultural Experiment Station, New Haven, Conn., U.S.A.
82. *Britton*, Mrs. W. E. (Associate).
83. *Brody*, A. L., 24 West 111th St., New York City, N.Y., U.S.A.
84. *Brower*, A. E., R. D. No. 2, Willard, U.S.A.
85. *Brown*, Professor F. M., Avon College, Conn., U.S.A.
86. *Brown*, W. J., Entomological Branch, Department for Agriculture, Ottawa, Canada.
87. Bruch, Professor Carlos, Calle Sarmiento 2544, Olivos, Prov. Buenos Aires, Argentina, S. A.
88. *Brues*, Professor C. T., Bussey Institution, Harvard University, 397 South Street, Jamaica Plain, Boston, Mass., U.S.A.
89. *Brues*, Mrs. C. T. (Associate).
90. *Burgess*, A. F., U.S. Department of Agriculture, Melrose Highlands, Mass., U.S.A.
91. *Burnside*, C. E., Bureau of Entomology, Washington, D.C., U.S.A.
*92. Burr, Malcolm, United Universities' Club, Pall Mall East, London, S.W 1., England.
93. *Busck*, A., U.S. Bureau of Entomology, Washington, D.C., U.S.A.
94. *Buys*, Professor J. L., St. Lawrence University, Canton, N.Y., U.S.A.
95. *Buys*, Mrs. J. L. (Associate).

96. *Caffrey*, D. J., U.S Bureau of Entomology, 615 Front St., Toledo, Ohio, U.S.A.
97. *Calvert*, Professor P. P., University of Pennsylvania, Philadelphia, Penna., U.S.A.
98. *Calvert*, Mrs. P. P. (Associate).
99. *Cameron*, M., Surgeon-Commander R. N., 15 Teesdale Rd., Leytonstone, London, E. 11, England.
100. *Campbell*, F. L., U.S. Bureau of Entomology, Washington, D. C., U.S.A.
*101. Carié, P., 40 boulevard de Courcelles, Paris, France.
102. *Carpenter*, Professor C. M., New York State Veterinary College, Cornell University, Ithaca, N.Y., U.S.A.
103. *Carroll*, J., National University of Ireland, University College, Dublin, Ireland.
104. *Carter*, W., U.S. Bureau of Entomology, Twin Falls, Idaho, U.S.A.
105. *Cassino*, S. E., Salem, Mass., U.S.A.
106. *Cattell*, Professor J. M., Garrison, N.Y., U.S.A.
107. *Cattell*, J., Garrison, N.Y., U.S.A.
108. *Ceballos*, G., Museo de Ciencias Naturales, Madrid, Spain.
109. *Cecil*, R., U.S. Bureau of Entomology, Geneva, N.Y., U.S.A.
110. *Chamberlin*, Professor R. V,, University of Utah, Salt Lake City, Utah, U.S.A.
111. Chang, H. S., Bureau of Entomology, Nanking, Kiangsu Province, China.
112. *Chapman*, P. J., Virginia Truck Experiment Station, Norfolk, Va., U.S.A.
113. *Chapman*, Mrs. P. J. (Associate).
114. *Chapman*, Professor R. N., University of Minnesota, St. Paul, Minn., U.S.A.
115. *Childs*, L., Agricultural Experiment Station, Hood River, Oregon, U.S.A.
116. Ciurea, Professor J., Facultate de Medicina veterinara, University, Bukarest, Rumania.
117. *Claassen*, Professor P. W., New York State College of Agriculture, Ithaca, N.Y., U.S.A.
118. *Claassen*, Mrs. P. W. (Associate).
119. *Clark*, Anna Whitman, 61 Bennett Ave., Binghamton, N.Y., U.S.A.
120. Cleare Jr., L. D., Dept. Agriculture, Entom. Division, Georgetown, Demerara, British Guiana.
121. *Colcord*, Mabel, Librarian, U.S. Bureau of Entomology, Washington, D.C., U.S.A.
122. *Collin*, J. E., Raylands, Newmarket, England.
123. *Collins*, C. W., U.S. Bureau of Entomology, 15 Boardman Ave., Melrose Highlands, Mass., U.S.A.
124. *Collins*, D. L., New York State Agricultural Experiment Station, Geneva, N.Y., U.S.A.
*125. Colonial Office, Downing Street, London, S.W. 1, England.
126. Committee of Civil Research, 2, Whitehall Gardens, London, S W. 1., England.

127. *Comstock,* Professor Anna B., Cornell University, Ithaca, N.Y., U. S. A.
128. *Comstock,* Professor J. H., Cornell University, Ithaca, N.Y., U.S.A.
129. *Coon,* Ethel L., U.S. Bureau of Entomology, Washington, D.C., U.S.A.
130. *Corporaal,* J. B., Zoological Museum, Amsterdam, Netherlands.
131. *Cory,* Professor E. N., University of Maryland, College Park, Md., U.S.A.
132. *Cory,* Mrs. E. N. (Associate).
133. *Cotton,* R. T., U.S. Bureau of Entomology, Washington, D.C., U.S.A.
134. *Craighead,* F. C., U.S. Bureau of Entomology, Washington, D.C., U.S.A.
135. *Crampton,* Professor G. C., Massachusetts Agricultural College, Amherst, Mass., U.S.A.
136. *Crampton,* Mrs. G. C. (Associate).
137. *Crawford,* H. G., Entomological Branch, Department for Agriculture, Ottawa, Canada.
138. *Crosby,* Professor C. R., New York State College of Agriculture, Ithaca, N.Y., U.S.A.
139. *Crosby,* Mrs. C. R. (Associate).
140. *Crossman,* S. S., U.S. Bureau of Entomology, 29 Pearl St., Melrose Highlands, Mass., U.S.A.
141. *Curran,* C. H., American Museum of Natural History, West 77th St., New York City, N.Y., U.S.A.
142. *Cutright,* C. R., Agricultural Experiment Station, Wooster, Ohio, U.S.A.
143. *Da Costa,* H. G., University of Missouri, Columbia, Mo., U.S.A.
144. *Dakessian,* V. S., c/o Dr. E. F. Phillips, Dairy Bldg., Cornell University, Ithaca, N.Y., U.S.A.
145. Dallas, E. D., Donato Alvarez 2125, Buenos Aires, Argentina, S.A.
146. *Dampf,* Professor A., Chief Entomologist, Mexican Government, Mexico City, Mexico.
147. *Danforth,* Professor S. T., University of Porto Rico, Mayagüez, Porto Rico.
148. *Daniel,* D. M., Agricultural Experiment Station, Geneva, N.Y., U.S.A.
149. *Davis,* Professor J. J., Purdue University, Lafayette, Ind., U.S.A.
150. *Davis,* W. T., 146 Stuyvesant Place, Staten Island, N.Y., U.S.A.
151. *Dean,* Professor G. A., Kansas State Agricultural College, Manhattan, Kansas, U.S.A.
152. *De Coursey,* Professor R. M., Louisiana State University, Baton Rouge, La., U.S.A.
153. *De Long,* Professor D. M., Ohio State University, Columbus, Ohio, U.S.A.
*154. Department of Agriculture, Pietermaritzburg, Natal, South Africa.
*155. Department of Agriculture, Pretoria, Transvaal, South Africa.
156. *Detwiler,* J. G., The Texas Company, 17 Battery Place, New York City, N.Y., U.S.A.
157. *Detwiler,* Professor J. D., University of Western Ontario, London, Ontario, Canada.
*158. Deutsches Entomologisches Institut der Kaiser Wilhelm-Gesellschaft, 20 Gosslerstrasse, Berlin-Dahlem, Germany.

159. *Dietrich*, H., Lucedale, Miss., U.S.A.
160. *Dingler*, Professor M., Universität Giessen, Giessen (Hessen), Germany.
161. *Dirks*, Professor C. O., University of Maine, Orono, Me., U.S.A.
162. *Dohanian*, S. M., U.S. Bureau of Entomology, 42 Cedar St., Somerville, Mass., U.S.A.
163. *Dobzhansky*, T., University of Leningrad, Laboratory of Genetics, Leningrad, U.S.S.R.
164. *Dozier*, Professor H. L., University of Delaware, Newark, Del., U.S.A.
165. *Dudley* Jr., J., U.S. Bureau of Entomology, 1532 University Ave., Madison, Wisc., U.S.A.
166. *Dunham*, W. E., Ohio State University, Columbus, Ohio, U.S.A.
167. *Dunham*, Mrs. W. E. (Associate).
168. *Du Porte*, Professor E. M., Macdonald College, McGill University, Quebec, Canada.
169. *Dye*, H. W., Middleport, N.Y., U.S.A.
170. *Eastham*, L. E. S., Zoological Department, University, Cambridge, England.
171. *Eaton*, T. H., 105 Brandon Place, Ithaca, N.Y., U.S.A.
*172. École de Médicine Tropicale, Bruxelles, Belgium.
173. *Eddy*, C. O., Clemson College, S. C., U.S.A.
174. *Eddy*, Mrs. C. O. (Associate).
175. *Edwards*, F. W., British Museum (Natural History), London, S.W. 7, England.
176. *Edwards*, Mrs. F. W. (Associate).
177. *Efflatoun Bey*, H. C., Assistant Professor of Zoology, Meadi, Cairo, Egypt.
178. *Eidmann*, Professor H. A., Forstliche Hochschule, Hannoversch-Münden, Germany.
179. *Elpind*, Amelia, Nassau Hospital, Mineola, L. I., N.Y., U.S.A.
180. *Ellsworth*, A. J., Johnson City, N.Y., U.S.A.
181. *Emerson*, Professor A. E., University of Chicago, Dept of Zoology, Chicago Ill., U.S.A.
182. *Enderlein*, Professor G., University of Berlin, Berlin, S.W. 11, Hafenplatz 3, Germany.
183. *Engelhardt*, G. P., Brooklyn Museum of Arts and Sciences, 373 Ocean Ave., Brooklyn, N.Y., U.S.A.
*184. Entomological Society of London, 41 Queen's Gate, London, S.W. 7, England.
185. Esaki, Professor T., Kyushu Imperial University, Fukuoka, Nippon.
186. Estación Experimental Agricola, Casilla 852, Lima, Peru, S. A.
187. *Evans*, H. C., Riverton, N. J., U.S.A.
188. *Farquhar*, D. W., 134 Professor's Row, Tufts College, Mass., U.S.A.
189. *Faust*, Professor E. C., Tulane University, New Orleans, La., U.S.A.
190. *Felt*, E. P., Bartlett Research Laboratory, Stamford, Conn., U.S.A.
191. Fenton, F. A., Bureau of Entomology, Box 67, Sta. A., El Paso, Texas, U.S.A.
192. *Ferris*, Professor G. F., Stanford University, Palo Alto, Cal., U.S.A.
193. *Filinger*, G. A., Ohio Agricultural Experiment Station, Wooster, Ohio, U.S.A.

194. *Filipjev,* I. N., University of Leningrad, Leningrad W. O. 2. 1. 13 Kv. 23, U. S. S. R.

195. *Filmer,* R. S., U. S. Bureau of Entomology, Washington, D. C., U. S. A.
196. *Fink,* D. E., U. S Bureau of Entomology, Washington, D. C., U. S. A.
197. *Fink,* Mrs. D. E. (Associate).
198. *Flanders,* S. E., Experiment Station, Riverside, Cal., U. S. A.
199. *Flanders,* Mrs. S. E. (Associate).
200. *Fletcher,* F. C., 1766 James Ave. South, Minneapolis, Minn., U. S. A.
201. Fletcher, Professor T. B., Agricultural Research Institute, Pusa, India.
202. *Flint,* H. M., Standard Oil Company of California, Richmond, Cal., U. S. A.

203. *Flint,* W. P., Illinois Natural History Survey & Agricultural Experiment Station, Urbana, Ill., U. S. A.

204. *Folsom,* J. W., U. S. Bureau of Entomology, Tallulah, La., U. S. A.
205. *Forbes,* Professor S. A., Illinois State Natural History Survey, Urbana, Ill., U. S. A.
206. *Forbes,* W. T. M., New York State College of Agriculture, Ithaca, N. Y., U. S. A.

207. *Ford,* Norma, University of Toronto, Ontario, Canada.
*208. Forest Entomologist, Forest Research Institute, Dehra Dun, U. P., British India.

209. *Fowler,* W. A., 112 Hilcrest Drive, Toronto, Canada.
210. *Fox-Wilson,* G., Waverley, West Byfleet, Surrey, England.
211. *Fracker,* S. B., U. S. Department of Agriculture, Washington, D. C., U. S. A.

212. *Francis,* E., Hygienic Laboratory, U. S. Public Health Service, Washington, D. C., U. S. A.

213. *Fraser,* Cora M. (Associate).
214. *Frison,* T. H., Illinois State Natural History Survey, Urbana, Ill., U. S. A.
215. *Frost,* Professor S. W., Pennsylvania State College, Arendtsville, Pa., U. S. A.

216. *Frost,* Mrs. S. W. (Associate).
217. *Frothingham,* Director E. H., Appalachian Forest Experiment Station, U. S. Forest Service, Biltmore, N. C., U. S. A.
218. *Fryer,* J. C. F., Plant Pathological Laboratory, Milton Road, Harpenden, England.

219. *Fulton,* B. B., North Carolina State College, Raleigh, N. C., U. S. A.
220. *Gahan,* A. B., U. S. National Museum, Washington, D. C., U. S. A.
221. *Gahan,* Mrs. A. B. (Associate).
222. *Gambrell,* F. L., New York State Agricultural Experiment Station, Geneva, N. Y., U. S. A.

223. *Geist,* Professor R. M., Capital University, Columbus, Ohio, U. S. A.
224. *Gentner,* L. G., Michigan State College, East Lansing, Mich., U. S. A.
225. *Gentner,* Mrs. L. G. (Associate).
226. *Gerhard,* W. J., Field Museum of Natural History, Chicago, Ill., U. S. A.
227. *Gerould,* Professor J. H., Dartmouth College, Hanover, N. H., U. S. A.

228. *Gibson*, A., Dominion Entomologist, Department for Agriculture, Ottawa, Canada.
*229. Girault, A. A., Brisbane, Queensland, Australia.
230. *Glance*, Grace E., U. S. Bureau of Entomology, Washington, D. C., U. S. A.
231. *Glasgow*, H., New York Agricultural Experiment Station, Geneva, N. Y., U. S. A.
232. *Glasgow*, R. D., State Entomologist, New York State Museum, Albany, N. Y., U. S. A.
233. *Glasgow*, Mrs. R. D. (Associate).
234. *Glassford*, J., McCormick & Co., Inc., Baltimore, Md., U. S. A.
235. *Goddard*, H. N., Western State Teachers' College, Kalamazoo, Mich., U. S. A.
236. *Goddard*, Mrs. H. N. (Associate).
237. *Good*, Professor H. G., Alabama Polytechnic Institute, Auburn, Ala., U. S. A.
238. *Gordon*, M., New York State College of Agriculture, Ithaca, N. Y., U. S. A.
239. *Gould*, A. C., Department of Agriculture & Markets, Albany, N. Y., U. S. A.
*240. Government of Natal, Durban, South Africa.
241. *Graf*, A., Servicio de Policia Sanitaria Vegetal, Santiago, Chile, S. A.
242. *Graham*, Professor S. A., University of Michigan, Ann Arbor, Mich., U. S. A.
243. *Graham*, Mrs. S. A. (Associate).
244. *Granovsky*, Professor A. A., University of Wisconsin, Madison, Wisc., U. S. A.
245. *Granovsky*, Mrs. A. A. (Associate).
246. *Gray*, Professor J., University of Florida, Gainesville, Fla., U. S. A.
*247. Green, E. E., Way's End, Beech Avenue, Camberley, England.
248. *Gridelli*, E., Museo Civico di Storia Naturale di Trieste, Trieste, Italy.
249. *Griswold*, Grace H., New York State College of Agriculture, Ithaca, N. Y., U. S. A.
250. *Gurney*, W. B., Department of Agriculture, Sydney, New South Wales, Australia.
251. *Guyton*, T. L., Pennsylvania Department of Agriculture, Harrisburg, Pa., U. S. A.
252. *Haber*, Professor V. R., Pennsylvania State College, State College, Pa., U. S. A.
253. *Haber*, Mrs. V. R. (Associate).
254. *Hadwen*, Professor S., University of Saskatchewan, Saskatoon, Saskatchewan, Canada.
255. *Hall*, M. C., Bureau of Animal Industry, U. S. Department of Agriculture, Washington, D. C., U. S. A.
256. *Hambleton*, E. J., New York State College of Agriculture, Ithaca, N. Y., U. S. A.
257. *Hambleton*, J. I., U. S. Bureau of Entomology, Washington, D. C., U. S. A.

258. *Hamilton*, W. J. Jr, New York State College of Agriculture, Ithaca, N. Y., U. S. A.
259. Handschin, A., University of Basel, Basel, Switzerland.
260. *Harned*, Professor R. W., Mississippi A. & M. College, A. & M. College, Miss., U. S. A.
261. *Harris*, Sarah L., 475 East 95th St., Brooklyn, N. Y., U. S. A.
262. *Hartnack*, H., 20 East Jackson Blvd., Chicago, Ill., U. S. A.
263. *Hartzell*, A., Boyce Thompson Institute for Plant Research, Yonkers, N. Y., U. S. A.
264. *Hartzell*, Mrs. A. (Associate).
265. *Hartzell*, F. Z., New York State Agricultural Experiment Station, Geneva, N. Y., U. S. A.
266. *Harwood*, R. D., San Diego, Cal., U. S. A.
267. *Harwood*, Mrs. R. D. (Associate).
268. *Harwood*, P. D., Rice Institute, Houston, Texas, U. S. A.
269. *Haseman*, Professor L., University of Missouri, Columbia, Mo., U. S. A.
270. *Haseman*, Mrs. L. (Associate).
271. *Haskins*, C. P., 1188 Avon Road, Schenectady, N. Y., U. S. A.
272. *Haskins*, Mrs. C. P. (Associate).
273. *Hawes*, Ina L., U. S. Bureau of Entomology, Washington, D. C., U. S. A.
274. *Hayes*, Professor W. P., University of Illinois, Urbana, Ill., U. S. A.
275. *Hayes*, Mrs. W. P. (Associate).
276. Hazelhoff, E. H., Pasoeroean, Java,
277. *Hazeltine*, K. S., 569 S. 10th St., San José, Cal., U. S. A.
278. *Headlee*, T. J., State Entomologist, New Brunswick, N. J., U. S. A.
279. *Heikertinger*, F., Wien XII-2, Thunhofgasse 8, Austria.
280. *Heinrich*, K., U. S. National Museum, Washington, D. C., U. S. A.
281. *Henriksen*, K. L., Zoological Museum, Copenhagen, Denmark.
*282. Henshaw, Professor S., Museum of Comparative Zoology, Cambridge, Mass., U. S. A.
283. *Hering*, P. E., 600 West 113th St., New York City, N. Y., U. S. A.
284. *Herms*, Professor W. B., University of California, Berkeley, Cal., U. S. A.
285. *Herrick*, Professor G. W., New York State College of Agriculture, Ithaca, N. Y., U. S. A.
286. *Herrick*, Mrs. G. W. (Associate).
287. *Hertig*, Professor M., Harvard Medical School, Boston, Mass., U. S. A.
288. *Hervey*, G. E. R., New York Agricultural Experiment Station, Geneva, N. Y., U. S. A.
289. Hetschko, Professor A., Kameral-Ellgoth, bei Teschen, Czechoslovakia.
290. *Hinds*, W. E., Louisiana Experiment Station, Baton Rouge, La., U. S. A.
291. *Hine*, Professor J. S., Ohio State University, Columbus, Ohio, U. S. A.
292. *Hinman*, E. H., Colborne, Ontario, Canada.
293. *Hodgkiss*, Professor H. E., Pennsylvania State College, State College, Pa., U. S. A.
294. *Holdaway*, F. G., University of Minnesota, St. Paul, Minn., U. S. A
295. *Holland*, W. J., 5545 Forbes St., Pittsburgh, Pa., U. S. A.

296. *Holloway*, T. E., U. S. Bureau of Entomology, 8203 Oak St., New Orleans, La., U. S. A.
297. *Hood*, Professor J. D., University of Rochester, Rochester, N. Y., U. S. A.
298. *Hooker*, W. A., U. S. Department of Agriculture, Washington, D. C., U. S. A.
299. *Hooker*, Mrs. W. A. (Associate).
300. *Hopkins*, A. D., U. S., Bureau of Entomology, Parkersburg, W. Va., U. S. A.
301. *Hopkins*, Mrs. A. D. (Associate).
302. *Horn*, W., Direktor, Deutsches Entomologisches Institut der Kaiser Wilhelm-Gesellschaft, 20 Gosslerstrasse, Berlin-Dahlem, Germany.
303. *Horsfall*, J. L., 597 Bellevue Ave., Yonkers, N. Y., U. S. A.
304. *Hose*, C., Redleaf, Riddlesdown Road, Purley, Surrey, England.
305. *Hose*, Mrs. C. (Associate).
306. *Hosmer*, Professor R. S., New York State College of Agriculture, Ithaca, N. Y., U. S. A.
307. *Hough*, W. S., Virginia Agricultural Experiment Station, 523 Fairmont Ave., Winchester, Va., U. S. A.
308. *Hough*, Mrs. W. S. (Associate).
309. *Houser*, J. S., Ohio Agricultural Experiment Station, Wooster, Ohio, U. S. A.
310. *Howard*, L. O., U. S. Bureau of Entomology, Washington, D. C., U. S. A.
311. *Howard*, Janet M. (Associate).
312. *Howard*, Lucy T. (Associate).
313. *Howard*, N. F., U. S. Bureau of Entomology, 151 West 11th Ave., Columbus, Ohio, U. S. A.
314. *Hubbell*, Professor T. H., University of Florida, Gainesville, Fla., U. S. A.
315. *Huber*, L. L., Ohio Agricultural Experiment Station, Wooster, Ohio, U. S. A.
316. *Huckett*, H. C., New York Agricultural Experiment Station, R. F. D., Calverton, L. I., N. Y., U. S. A.
317. Hungarian Entomological Society, Kitaibel Pál-Utca I. Szám, Budapest II, Hungary.
318. Hungerford, Professor H. B., University of Kansas, Lawrence, Kansas, U. S. A.
319. *Hyslop*, J. A., U. S. Bureau of Entomology, Washington, D. C., U. S. A.
320. *Ilg*, C., Rutgers College, New Brunswick, N. J., U. S. A.
321. Imhof, O. E., Königsfelden (Aargau) Switzerland.
322. *Imms*, A. D., Rothamsted Experimental Station, Harpenden, England.
*323. Imperial Bureau of Entomology, 41 Queen's Gate, London, S.W. 7, England.
*324 Indian Museum, Calcutta, British India.
225. Ingram, J. W., Rice Insect Investigations, Crowley, La., U. S. A.
326. *Inomata*, Professor S., Imperial College of Agriculture, Tottori, Nippon.

*327. Institut Agricole, Gembloux, Belgium.
328. Jablonowski, J., Hungarian Agricultural Experiment Station, II Kitaibel Pál-Utca I. Szám, Budapest II, Hungary.
329. *Jackson,* Dorothy J., North Cliff, St. Andrews, Fife, Gt. Britain.
330. Jaczewski, T., Panstwowe Muzeum Przyrodnicze, Dzial Zoologicznij, Krak.-Przedmieście 26—28, Warszawa, Poland.
331. Jarvis, E., Bureau of Sugar Experiment Stations, Cairns, Queensland, Australia.
332. *Jeannel,* Professor R., Muséum National d'Histoire Naturelle, 57, rue Cuvier, Paris Ve, France.
333. *Johannsen,* Professor O. A., New York State College of Agriculture, Ithaca, N. Y., U. S. A.
334. *Johannsen,* Mrs. O. A. (Associate).
335. *Johannsen,* Dorothea E. (Associate).
336. *Johnson,* C. W., Boston Society of Natural History, Boston, Mass., U. S. A.
337. *Jones,* F. M., 2000 Riverview Ave., Wilmington, Delaware, U. S. A.
338. *Jones,* Mrs. F. M. (Associate).
339. *Jones,* M. P., Ohio State University, Columbus, Ohio, U. S. A.
340. *Jones,* S. C., New York State College of Agriculture, Ithaca, N. Y., U. S. A.
*341. *Jordan,* K., Zoological Museum, Tring (Herts.), England.
342. *Jordan,* Ada (Associate).
343. *Jordan,* Hildegard (Associate).
344. Jung, G. P., Director, Bureau of Entomology, Nanking, Kiangsu Province, China.
345. *Kahl,* P. H. I., Carnegie Museum, Pittsburgh, Pa., U. S. A.
346. Kannan, K. Kunhi, Entomologist, Department of Agricultural Research, Bangalore, Mysore State, S. India.
347. *Kashkarov,* Professor D., Middle Asiatic University, Tashkent, Russia (Associate).
348. *Kelsall,* A., Entomological Branch, Department for Agriculture. Ottawa, Canada.
349. *Kemner,* N. A., Clemenstorget 12, Lund, Sweden.
350. *Kennedy,* Professor C. H., Ohio State University, Columbus, Ohio, U. S. A.
351. King, H. H., Government Entomologist, Khartoum, Sudan.
352. *King,* K. M., Entomological Branch, Department for Agriculture, Saskatoon, Saskatchewan, Canada.
353. *King,* Professor R. L., University of Pennsylvania, Philadelphia, Pa., U. S. A.
354. *King,* W. V., U. S. Bureau of Entomology, Mound, La., U. S. A.
355. *King,* Mrs. W. V. (Associate).
356. Kleine, Direktor R., Werderstrasse 31, Stettin, Germany.
357. *Klots,* A. B., New York State College of Agriculture, Ithaca, N. Y., U. S. A.
358. *Klots,* Mrs. A. B. (Associate).
359. Klynstra. B. H., Frankenstraat 60, The Hague, Netherlands.
360. *Knechtel,* W. K., Department of Agriculture, Bukarest, Roumania.

361. *Knight*, Professor H. H., Iowa State College, Ames, Iowa, U. S. A.
362. *Knight*, H. L., U. S. Department of Agriculture, Washington, D. C., U. S. A.
363. *Knight*, Mrs. H. L. (Associate).
364. *Knull*, J. N., Pennsylvania Bureau of Plant Industry, Harrisburg, Pa., U. S. A.
365. Köhler, K. F., 21 Täubchenweg, Leipzig, Germany.
366. Kolbe, Professor H., Steinäckerstrasse 12, Berlin-Lichterfelde, Germany.
367. *Kryger*, I. P., 12 Rosenvej, Gentofte, Denmark.
368. *Kuhn*, Lieut., H. A., Chemical Warfare Depot, Corozal, Canal Zone, Panama.
369. Kuwana, I., Ministry of Agriculture & Forestry, Tokyo, Nippon.
370. Kuwayama, S., Hokkaido Agricultural Experiment Station, Kotoni, Sapporo, Nippon.
371. Laboratorio di Entomologia del R. Instituto Superiore Agrario di Portici (Napoli), Italy.
372. *Lamson* Jr., Professor G. H., Connecticut Agricultural College, Storrs, Conn., U. S. A.
373. *Landis*, B. J., U. S. Bureau of Entomology, Geneva, N. Y., U. S. A.
374. *Langford*, G. S., Agricultural Experiment Station, Wooster, Ohio, U. S. A.
375. *Larrimer*, W. H., U. S. Bureau of Entomology, Washington, D. C., U. S. A.
376. *Lathy*, P. L., 90 Bould. Malesherbes, Paris, France.
377. *Lawson*, Professor P. B., University of Kansas, Lawrence, Kansas, U. S. A.
378. *Learned*, E. T., 46 Franklin St., Fall River, Mass., U. S. A.
379. *Lebowitz*, W. G., Kny-Scheerer Corporation of America, 10—14 West 25th Street, New York City, N. Y., U. S. A.
380. Leefmans, S., Directeur van het Instituut voor Plantenziekten, Buitenzorg, Java.
381. *Leiby*, R. W., State Entomologist, Raleigh, N. C., U. S. A.
382. *Leng*, Director, C. W., Staten Island Institute of Arts & Sciences, Staten Island, N. Y., U. S. A.
383. *Leonard*, M. D., Roberts Hall, Ithaca, N. Y., U. S. A.
*384. Levick, John, Ashley House, Handsworth Wood, Birmingham, England.
385. *List*, Professor G. M., Colorado Agricultural College, Fort Collins, Colorado, U. S. A.
*386. Literary and Philosophical Society, Newcastle-upon-Tyne, England.
387. *Little*, Professor V. A., Texas Agricultural & Mechanical College, College Station, Texas, U. S. A.
388. *Little*, Mrs. V. A. (Associate).
389. *Lloyd*, J. T., Court & Plum Sts., Cincinnati, Ohio, U. S. A.
390. *Lochhead*, A. G., Dominion Experimental Farms, Ottawa, Canada.
391. *Luginbill*, P., U. S. Bureau of Entomology, Monroe, Mich., U. S. A.
392. *Lutz*, F. E., American Museum of Natural History, West 77th St., New York City, N. Y., U. S. A.

393. *MacAloney*, H. J., U. S. Bureau of Entomology, Amherst, Mass., U. S. A.
394. *MacDaniel*, Professor L. H., New York State College of Agriculture, Ithaca, N. Y., U. S. A.
395. MacDougall, Professor R. Stewart, 9 Dryden Place, Blacket Ave., Edinburgh, Gt. Britain.
396. MacGillavry, D., Jan Willem Brouwersplein 9, Amsterdam, Netherlands.
397. *MacLeod*, G. F., Pennsylvania State College, State College, Pa., U. S. A.
398. *Mackie*, D. B., State Department of Agriculture, Sacramento, Cal., U. S. A.
399. Magyar Nemzeti Museum, Budapest, Hungary.
400. *Maheux*, G., Laval University, Quebec City, Canada.
401. *Mann*, Dean A. R., New York State College of Agriculture, Ithaca, N. Y., U. S. A.
402. *Manter*, Professor J. A., Connecticut Agricultural College, Storrs, Conn., U. S. A.
403. *Marcovitch*, S., Tennessee Agricultural Experiment Station, Knoxville, Tenn., U. S. A.
404. *Marlatt*, C. L., Chief, U. S. Bureau of Entomology and Plant Quarantine Administration, Washington, D. C., U. S. A.
405. *Marsden*, E., Council of Scientific & Industrial Research, Wellington, New Zealand.
406. *Marshall*, Professor W. S., University of Wisconsin, Madison, Wisc., U. S. A.
407. *Martini*, Professor E., Institut für Schiffs- und Tropenkrankheiten, Hamburg 4, Bernhard Nocht-Str. 74, Germany.
408. *Martynov*, A. B., Zoological Museum, Academy of Sciences, Leningrad, U. S. S. R.
409. Maruzen Co., Ltd., Tokyo, Nippon.
410. *Mason*, P. W., U. S. Bureau of Entomology, Washington, D. C., U. S. A.
411. *Mason*, Mrs. P. W. (Associate).
412. *Matheson*, Professor R., New York State College of Agriculture, Ithaca, N. Y., U. S. A.
413. *Matheson*, Mrs. R. (Associate).
414. *Matteson*, J. H., 27 N. W. 7th Ave., Miami, Fla., U. S. A.
415. *McBride*, O. C., U. S. Bureau of Entomology, Orlando, Fla., U. S. A.
416. McColloch, Professor J. W., Kansas State Agricultural College, Manhattan, Kansas, U. S. A.
417. *McDonnough*, F. L., Middleport, N. Y., U. S. A.
418. *McIndoo*, N. E., U. S. Bureau of Entomology, Washington, D. C., U. S. A.
419. *McIndoo*, Mrs. N. E. (Associate).
420. *McIntyre*, H. L., New York State Department of Conservation, Albany, N. Y., U. S. A.
421. *McLaine*, L. S., Department of Agriculture, Ottawa, Canada.
422. de Meijere, J C. H., Stadhouderskade 135, Amsterdam, Holland.

423. *Melander*, Professor A. L., College of the City of New York, New York City, N. Y., U. S. A.
424. *Melander*, Mrs. A. L. (Associate).
425. *Mengel*, Director L. W., Reading Public Museum, Reading, Pa., U. S. A.
426. *Mickel*, Professor C. E., University of Minnesota, St. Paul, Minn., U. S. A.
427. *Mickel*, Mrs. C. E. (Associate).
428. *Middleton*, W., U. S. Bureau of Entomology, Washington, D. C., U. S. A.
429. Miller, J. M., Senior Entomologist, Stanford University, Cal., U. S. A.
430. *Mills*, A. S., 655 Riverside Drive, New York City, N. Y., U. S. A.
431. Ministry of Agriculture, Wellington Place, Belfast, N. Ireland.
432. Ministry of Agriculture and Fisheries, Whitehall Gardens, London, W. 1, England.
433. *Minns*, Lua A., New York State College of Agriculture, Ithaca, N. Y., U. S. A.
434. *Mitchell*, Professor T. B., North Carolina State College, Raleigh, N. C., U. S. A.
435. *Mitchener*, Professor A. V., University of Manitoba, Winnipeg, Manitoba, Canada.
436. Michigan State College, East Lansing, Mich., U. S. A.
437. *Morgan*, Professor Ann H., Mt. Holyoke College, South Hadley, Mass., U. S. A.
438. *Morrison*, H., Bureau of Entomology, Washington, D. C., U. S. A.
439. *Morrison*, Mrs. H. (Associate).
440. *Morse*, A. P., Peabody Museum of Salem, 16 Upland Road, Wellesley, Mass., U. S. A.
441. *Mote*, Professor D. C., Oregon Agricultural College, Corvallis, Ore., U. S. A.
442. *Muir*, F. A. G., Hawaiian Sugar Planters' Experiment Station, Honolulu, T. H., Sandwich Islands.
443. *Muller*, Professor A. S., College of Agriculture & Mechanical Arts, Mayagüez, Porto Rico.
444. *Mumford*, E. P., Bishop Museum, Honolulu, T. H., Sandwich Islands.
445. *Mundinger*, F. G., 413 East Cedar St., Poughkeepsie, N. Y., U. S. A.
446. *Munns*, E. N, Chief, Office of Forest Experiment Station, U. S. Department of Agriculture, Washington, D. C., U. S. A.
447. *Munro*, Professor J. A., North Dakota State College, Fargo, N. D., U. S. A.
448. *Munro*, Mrs. J. A. (Associate).
*449. Musée du Congo Belge, Tervueren, Bruxelles, Belgium.
*450. Musée Forestier, Jardin Botanique, Bruxelles, Belgium.
*451. Musée Royal d'Histoire Naturelle, 31 rue Vautier, Bruxelles, Belgium.
*452. Museum of Comparative Zoology, Cambridge, Mass., U. S. A.
453. *Musgrave*, P., 514 Mt. Vernon Ave., Fairmont, W. Va.. U. S. A.
454. *Nadler*, A. M., 479 East 7th Street., Brooklyn, N. Y., U. S. A.
455. *Natvig*, L. R., Zoological Museum, University, Oslo, Norway.
456. Navás, L., Colegio del Salvador, Apartado 32, Zaragoza, Spain.

457. *Needham*, Professor J. G., New York State College of Agriculture, Ithaca, N. Y., U. S. A.
458. *Needham*, Mrs. J. G. (Associate).
459. *Needham*, Annabel (Associate).
460. *Needham*, P. R., New York State College of Agriculture, Ithaca, N. Y., U. S. A.
461. *Needham*, Mrs. P. R. (Associate).
462. *Neiswander*, C. R., Ohio Agricultural Experiment Station, 550 Church St., Oak Harbor, Ohio, U. S. A.
463. *Nelson*, E., 710 Gardan St., Carlstadt, N. J., U. S. A.
464. *Nelson*, F. C., 414 Chestnut St., Roselle Park, N. J., U. S. A.
465. Newcomb, Dr. W. N., 48 Webb Avenue, Detroit, Mich., U. S. A.
466. Newcomer, E. J., Bureau of Entomology, Box 243, Yakima, Washington, U. S. A.
467. *Newman*, Professor G. B., Pennsylvania State College, State College, Pa., U. S. A.
468. *Nikolsky*, V., Moscow Tropical Institute, Moscow, U. S. S. R.
469. *Nolla*, J. A. B., Insular Experiment Station, Rio Piedras, Porto Rico.
470. *Nonell*, Director J., Stación Patologica, Barcelona, Spain.
471. *Novella*, J. M., Representative of the Government of Guatemala, 19 West 69 th St., New York City, N. Y., U. S. A.
*472. Northamptonshire Natural History Society and Field Club, Northampton, England.
473. *Oertel*, E., Southern States Bee Culture Field Station, University Station, Baton Rouge, La., U. S. A.
474. *Oertel*, Mrs. E. (Associate).
475. *Olsen*, C. E., American Museum of Natural History, West 77 th Street, New York City, N. Y., U. S. A.
476. *de Ong*, E. R., 862 Regal Road, Berkeley, Cal., U. S. A.
477. *d'Orchymont*, A. H., Avenue Houba de Strooper 176, Bruxelles, Belgium.
478. *d'Orchymont*, Louise B. (Associate).
479. *Osborn*, Professor H., Ohio State University, Columbus, Ohio, U. S. A.
490. *Osburn*, Professor R. C., Ohio State University, Columbus, Ohio, U. S. A.
481. *Osburn*, Mrs. R. C. (Associate).
482. Oudemans, J. Th., Putten, Gelderland, Netherlands.
483. *Packard*, C. M., U. S. Bureau of Entomology, Box 495, West Lafayette, Ind., U. S. A.
484. *Pallister*, J. C., Cleveland Museum of Natural History, Cleveland, Ohio, U. S. A.
485. *Pallister*, Mrs. J. C. (Associate).
486. *Parfentjev*, I. A., Laboratory for Research in Insecticides and Fungicides, Moscow, U. S. S. R.
487. *Park*, A. R., 308 Romine St., Urbana, Ill., U. S. A.
488. *Parker*, J. R., Montana Agricultural Experiment Station, Bozeman, Mont., U. S. A.
489. *Parker*, Mrs. J. R. (Associate).

490. *Parker*, Professor R. L., Kansas State Agricultural College, Manhattan, Kansas, U. S. A.
491. *Parker*, Mrs. R. L. (Associate).
492. *Parker*, R. R., U. S. Public Health Service, Hamilton, Mont., U. S. A.
493. *Parks*, Professor T. H., Ohio State University, Columbus, Ohio, U. S. A.
494. *Parrott*, Professor P. J., New York State Agricultural Experiment Station, Geneva, N. Y., U. S. A.
495. *Parrott*, Mrs. P. J. (Associate).
496. *Parshley*, Professor H. M., Smith College, Northampton, Mass., U. S. A.
497. *Parten*, H. L., University of Minnesota, Minneapolis, Minn., U. S. A.
498. *Patch*, L. H., U. S. Bureau of Entomology, Sandusky, Ohio, U. S. A.
499. *Pate*, Y. S. D., 5703 N. Sixth St., Philadelphia, Pa., U. S. A.
500. *Payne*, Mrs. C. H. (Associate).
501. *Pepper*, J O., Pennsylvania State College, State College, Pa., U. S. A.
502. *Peters*, H. S., U. S. Bureau of Entomology, Washington, D. C., U. S. A.
503. *Peters*, L. A. H., Royal Netherland Legation, 1470 Euclid St., Washington, D. C., U. S. A.
504. *Peters*, Mrs. L. A. H. (Associate).
505. *Pettey*, F. W., Department of Agriculture, Union of South Africa, Elsenburg, Mulders Vlei, Cape Province, South Africa.
506. *Pettey*, Mrs. F. W. (Associate).
507. *Phillips*, Professor E. F., New York State College of Agriculture, Ithaca, N. Y., U. S. A.
508. *Phillips*, Mrs. E. F. (Associate).
509. *Phillips*, M. E., 508 Edgewood Place, Ithaca, N. Y., U. S. A.
510. *Poos*, F. W., U. S. Bureau of Entomology, Clarendon, Va., U. S. A.
511. *Poos*, Mrs. F. W. (Associate).
512. *Popenoe*, C. H., U. S. Bureau of Entomology, Washington, D. C., U. S. A.
513. *Porter*, B. A., U. S. Bureau of Entomology, Vincennes, Ind., U. S. A.
*514. Poulton, Professor E. B., Hope Department, University Museum, Oxford, England.
515. Prell, Professor H., Forstliche Hochschule, Tharandt, Sachsen, Germany.
516. *Price*, Professor W. A., Purdue University, Lafayette, Ind., U. S. A.
517. *Prince*, A. R., Nova Scotia Agricultural College, Truro, Nova Scotia.
518. *Prout*, L. B., 84 Albert Road, Dalston, London, E. 8, England.
519. *Quaintance*, A. L., U. S. Bureau of Entomology, Washington, D. C., U. S. A.
520. *Quayle*, Professor H. J., University of California, Riverside, Cal., U. S. A.
521. *Rambousek*, F. G., Czechoslovakian Sugar Industry Research Institute, Prague, Czechoslovakia.
522. *Rea*, G. H., Reynoldsville, Pa., U. S. A.
523. *Rea*, Mrs. G. H. (Associate).
524. *Reed*, Professor H. D., Cornell University, Ithaca, N. Y., U. S. A.

525. *Reeves*, G. I., U. S. Bureau of Entomology, Salt Lake City, Utah, U. S. A.
526. *Regnier*, R., Directeur de la Station Entomologique et du Muséum de Rouen, Rouen, France.
527. *Regnier*, Mrs. R. (Associate).
528. *Ressler*, I. L., 706 6th Ave., New York City, N. Y., U. S. A.
529. *Reveley*, Professor Ida L., Wells College, Aurora, N. Y., U. S. A.
530. *Richards*, O. W., Imperial College of Science & Technology, London, England.
531. *Richardson*, H. H., Millis, Mass., U. S. A.
532. *Ries*, D. T., 401 Thurston Ave., Ithaca, N. Y., U. S. A.
533. *Riley*, N. D., British Museum (Natural History), London, S. W. 7, England.
534. *Riley*, Professor W. A., University of Minnesota, St. Paul, Minn., U. S. A.
535. *Riley*, Mrs. W. A. (Associate).
536. *Riley*, Alice L. (Associate).
537. *Rimsky-Korsakov*, Professor M., Forest Institute and University, Leningrad, U. S. S. R.
538. *Rincones*, P. R., Venezuelan Consul General in New York, 113 Broad Street, New York City, N. Y., U. S. A.
539. *Roark*, R. C., U. S. Bureau of Chemistry & Soils, Washington, D. C., U. S. A.
540. *Roepke*, Professor W. K. F., Institute of Phytopathology, Wageningen, Netherlands.
541. *Rogers*, Professor J. S., University of Florida, Gainesville, Fla., U. S. A.
542. *Root*, Professor F. M., Johns Hopkins University, Baltimore, Md., U. S. A.
543. *Root*, Mrs. F. M. (Associate).
544. *Rosen*, Baron K. von, Zoologische Staatssamlung, Neuhauserstraße 51, München, Germany.
545. *Ross*, W. A., Vineland Station, Ontario, Canada.
546. Ronzoni, Professor E., Washington University Medical School, St. Louis, Mo., U. S. A. (Associate).
*547. Rothschild, The Right Hon. Lord, Zoological Museum, Tring, Herts., England.
548. *Ruckes*, H., College of the City of New York, New York City, N. Y., U. S. A.
549. *Ruckes*, Mrs. H. (Associate).
550. *Rudolfs*, Professor W., Rutgers University, New Brunswick, N. J., U. S. A.
551. *Ruggles*, Professor A. G., University of Minnesota, St. Paul, Minn., U. S. A.
552. *Rumsey*, W E., State Entomologist, Morgantown, W. Va., U. S. A.
553. *Runyon*, Elizabeth C. Miami, Fla. (Associate).
554. *Russell*, Louise M., U. S. Bureau of Entomology, Washington, D. C., U. S. A.
555. *Ryberg*, M. E., 1086 N. Broadway, Yonkers, N. Y., U. S. A.
556. *Saalas*, Professor U., University of Helsinki, Cygnaeuksenk 4 B, Helsinki, Finland.

557. *Saalas*, Mrs. U. (Associate).
558. *Sainte-Claire Deville*, J. E., Directeur des Laboratoires des Mines de la Sarre, Virchowstrasse 12, Saarbrücken, Saargebiet, Germany.
559. *Salt*, G., 412 19th Ave. N. W., Calgary, Alberta, Canada.
560. *Šámal*, Professor J., College of Agriculture, University, Prag II, Karlow 3, Zoolog. Institute, Prague, Czechoslovakia.
561. *Sanders*, J. G., Sun Oil Co., Philadelphia, Pa., U. S. A.
562. *Sanderson*, Professor D., New York State College of Agriculture, Ithaca, N. Y., U. S. A.
563. *Sanderson*, Mrs. D. (Associate).
564. *Sanford*, H. L., Plant Quarantine & Control Administration, Washington, D. C., U. S. A.
565. Sanninos, A., Counsellor of the Greek Legation, Washington, D. C., U. S. A.
566. *Schaffner*, J. V., U. S. Bureau of Entomology, Dover, Mass., U. S. A.
567. *Schindler*, Theresa E., School of Horticulture for Women, Ambler, Pa., U. S. A.
568. *Schmieder*, R. G., University of Pennsylvania, Philadelphia, Pa., U. S. A.
569. *Schoene*, Professor W. J., Virginia Agricultural Experiment Station, Blacksburg, Va., U. S. A.
570. Schulthess, A. von, Wasserwerkstrasse 53, Zürich, Switzerland.
571. *Schwartz*, M. K. O., Biologische Reichsanstalt für Land- und Forstwirtschaft, Berlin-Dahlem, Germany.
572. *Scotland*, Minnie B., New York State College for Teachers, Albany, N. Y., U. S. A.
573. *Scott*, J. P., 5354 Delmar Boulevard, St. Louis, Mo., U. S. A.
574. *Scullen*, Professor H. A., Oregon State Agricultural College, Corvallis, Ore., U. S. A.
575. *Searls*, E. M., U. S. Bureau of Entomology, Madison, Wisc., U. S. A.
576. *Senning*, W. C., 115 Crook St., Ithaca, N. Y., U. S. A.
577. *Shadle*, Professor A. R., University of Buffalo, N. Y., U. S. A.
578. *Shannon*, R. C., 644 Sixth Northeast, Washington, D. C., U. S. A.
579. *Shapiro*, Dorothy, 1087 Lexington Ave., New York City, N. Y., U. S. A.
580. *Sherman* Jr., J. D., 132 Primrose Ave., Mount Vernon, N. Y., U. S. A.
581. *Sherman*, Mrs. J. D. (Associate).
582. *Sherman*, Elizabeth (Associate).
584. Shiraki, Professor T., Taihoku Imperial University, Taihoku, Taiwan, Nippon.
584. *Sibley*, C. K., John Burroughs School, Clayton, Mo., U. S. A.
585. *Siegel*, M., 1051 East 14th St., Brooklyn, N. Y., U. S. A.
586. *Silvela*, F., Attaché to the Spanish Embassy, Washington, D. C., U. S. A.
587. *Silvestri*, Professor F., R. Instituto Superiore Agrario, Portici, Italy.
588. *Skaife*, S. H., Department of Education, Cape Town, South Africa.
589. *Skwarra*, Elisabeth, Mozartstrasse 10 II., Königsberg, Preussen, Germany.
590. *Slocum*, B. A., New York State College of Agriculture, Ithaca, N. Y., U. S. A.

591. *Slocum*, Mrs. B. A. (Associate).
592. *Smith*, F. F., Pennsylvania Bureau of Plant Industry, Harrisburg, Pa., U. S. A.
593. *Smith*, Professor H. S., University of California, Riverside, Cal., U. S. A.
594. *Smith*, L. B., U. S. Bureau of Entomology, Moorestown, N. J., U. S. A.
595. *Smulyan*, M. T., U. S. Bureau of Entomology, Melrose Highlands, Mass., U. S. A.
596. *Smyth*, E. G., 25 E. Mosholu Parkway, New York City, N. Y., U. S. A.
597. *Snodgrass*, R. E., U. S. Bureau of Entomology, Washington, D. C., U. S. A.
598. *Snodgrass*, Mrs. R. E. (Associate).
599. *Snyder*, T. E., U. S. Bureau of Entomology, Washington, D. C., U. S. A.
600. *Snyder*, Mrs. T. E. (Associate).
*601. Société Entomologique de Belgique, Université Libre, Bruxelles, Belgium.
602. *Sowder*, W. J., Radford State Teachers' College, Radford, Va., U. S. A.
603. *Spaeth*, Professor J. N., New York State College of Agriculture, Ithaca, N. Y., U. S. A.
604. *Spencer*, Professor G. J., University of British Columbia, Vancouver, B. C., Canada.
605. *Stanford*, J. S., 129 Kline Road, Ithaca, N. Y., U. S. A.
606. *Stanford*, Mrs. J. S. (Associate).
*607. Stadtbibliothek, Hamburg, Germany.
608. *Stellwaag*, Professor F., Staatliche Lehr- und Versuchsanstalt für Wein- und Obstbau, Neustadt a. Haardt, Germany.
609. *Stene*, A. E., State Department of Agriculture, Kingston, R. I., U. S. A.
610. *Stewart*, M. A., Rice Institute, Houston, Texas, U. S. A.
611. *Stewart*, Mrs. M. A. (Associate).
612. *Stiles*, Professor C. W., U. S. Public Health Service, Hygienic Laboratory, Washington, D. C., U. S. A.
613. *Stone*, A., New York State College of Agriculture, Ithaca, N. Y., U. S. A.
614. *Strand*, Professor A. L., University of Minnesota, St. Paul, Minn., U. S. A.
615. *Streda*, Professor R., Jozsef ut. 15. II. 22, Budapest VIII, Hungary.
616. *Sturtevant*, A. P., U. S. Intermountain Bee Culture Field Station, Laramie, Wyo., U. S. A.
617. *Sullivan*, Professor K. C., University of Missouri, Columbia, Mo., U. S. A.
618. *Swenk*, Professor M. H., University of Nebraska, Lincoln, Neb., U. S. A.
619. *Swett*, L. W., Agassiz Museum, Lexington, Mass., U. S. A.
620. *Swezey*, O. H., Experiment Station of the Hawaiian Sugar Planters' Association, Honolulu, T. H., Sandwich Islands.
621. *Swezey*, Mrs. O. H. (Associate).
622. *Talbot*, G., The Hill Museum, Witley, England.

623. *Tams,* W. H. T., British Museum (Natural History), Cromwell Road, London, S. W. 7, England.
624. *Tanner,* Professor V. M., Brigham Young University, Provo, Utah, U. S. A.
625. *Tanner,* Mrs. V. M. (Associate).
626. *Taylor,* R. L., 397 South St., Forest Hills, Mass., U. S. A.
627. *Taylor,* Mrs. R. L. (Associate).
628. *Thomas,* Professor C. A., Pennsylvania State College, Bustleton, Philadelphia Pa., U. S. A.
629. *Thompson,* C. S., Entomological Branch, Department of Agriculture, Ottawa, Canada.
630. *Thomsen,* Professor M., Royal Veterinary & Agricultural College, Copenhagen, Denmark.
631. *Thone,* F., Science Service, Washington, D. C., U. S. A.
632. *Tietz,* H. M., Pennsylvania State College, State College, Pa., U. S. A.
633. *Tillyard,* R. J., Chief Commonwealth Entomologist, Canberra, F. C. F., Australia.
634. *Timberlake,* P. H., Citrus Experiment Station, Riverside, Cal., U. S. A.
635. *Torre-Bueno,* J. R., 34 De Kall Ave., White Plains, N. Y., U. S. A.
636. *Torre-Bueno,* Mrs. J. R. (Associate).
637. *Torres,* D. D. de, Instituto Nacional de Investigaciones Agronomicas, Madrid, Spain.
638. *Trägårdh,* Professor I., Royal Swedish Forest Experiment Station, Stockholm 50, Sweden.
639. *Trägårdh,* Mrs. I. (Associate).
*640. Transvaal Museum, Pretoria, Transvaal, South Africa.
641. *Treadwell,* Professor A. L., Vassar College, Poughkeepsie, N. Y., U. S. A.
642. *Trouvelot,* B., Centre de Recherches Agronomiques, Route de St. Cyr, Versailles, France.
643. *Tschorbadjiev,* P. D., Institut des Recherches Agronomiques, Patriarch Eftimi, 46, Sofia, Bulgaria.
644. *Tully,* Eva M., 540 West 123rd St., New York City, N. Y., U. S. A.
645. Turner, H. J., Latemar, West Drive, Cheam, England.
646. *Turner,* Margaret V., Middle Road, Box 113, Oswego, N. Y., U. S. A.
647. *Tyson,* W. C., Gasport, N. Y., U. S. A.
648. Uyttenboogaart, D. L., Utrechtsche Straatweg 51, Renkum, Netherlands.
649. Valck Lucassen, F. T., Korte Parkweg 1, Bloemendaal, Netherlands.
650. *Van Dine,* D. L., Cuba Sugar Club Experiment Station, Central Baragua, Provincia de Camagüey, Cuba.
651. *Van Doren,* Lurana C., 723 8th St. N. E., Washington, D. C., U. S. A.
652. *Van Duzee,* E. P., California Academy of Sciences, San Francisco, Cal., U. S. A.
653. *Van Duzee,* Mrs. E. (Associate).
654. *Van Duzee,* M. C., 12 Abbotsford Place, Buffalo, N. Y., U. S. A.
655. *Van Dyke,* Professor E. C., University of California, Berkeley, Cal., U. S. A.

656. *Vappula*, N. A., Agricultural Experiment Station, Tikkurila, Suomi, Finland.
657. *Varrelman*, Professor F. A., American University, Washington, D. C., U. S. A.
658. *Vayssière*, P., Directeur-Adjoint, Station Centrale d'Entomologie de Paris, 16 rue Claude-Bernard, Paris, France.
659. Verity, Roger, Via Masaccio 36, Firenze, Italy.
660. *Vorhies*, Professor C. T., University of Arizona, Tucson, Arizona, U. S. A.
661. *Wade*, J. S., U. S. Bureau of Entomology, Washington, D. C., U. S. A.
662. *Wakeley*, P. C., Southern Forest Experiment Station, 326 Custom House, New Orleans, La., U. S. A.
663. *Walker*, H. W., Chemical Warfare Service, Edgewood Arsenal, Md., U. S. A.
664. *Walley*, G. S., Entomological Branch, Department of Agriculture, Ottawa, Canada.
665. *Walton*, Professor, G. W., Albright College, Myerstown, Pa., U. S. A.
666. *Wang*, C. C., The Science Society of China, Nanking, China.
667. *Watanabe*, K., Imperial Experiment Station of Sericulture, Tokyo, Nippon.
668. *Waterston*, J., British Museum (Natural History), London, S. W. 7, England.
669. *Watson*, L. R., Alfred, N. Y., U. S. A.
670. *Webster*, Professor R. L., Washington State College, Pullman, Wash., U. S. A.
671. *Weed*, A., University of Wisconsin, Madison, Wisc., U. S. A.
672. *Wehrle*, L. P., New York State College of Agriculture, Ithaca, N. Y., U. S. A.
673. *Wehrle*, Mrs. L. P. (Associate).
674. *Weingast*, J., 251 Herzl St., Brooklyn, N. Y., U. S. A.
675. *Weingast*, Sophie M., 251 Herzl St., Brooklyn, N. Y., U. S. A.
676. *Weld*, L. H., East Falls Church, Va., U. S. A.
677. *Weld*, Mrs. L. H. (Associate).
678. *Wells*, M. M., General Biological Supply House, Palos Park, Ill., U. S. A.
679. *Wells*, R. W., U. S. Bureau of Entomology, Washington, D. C., U. S. A.
680. *Werner*, R. W. H., 24 Ardaven Place, London, Ont., Canada.
681. *Wheeler*, E. H., Hobart College, Geneva, N. Y., U. S. A.
682. *Wheeler*, Professor G. C., University of North Dakota, Grand Forks, N. Dak., U. S. A.
683. *Wheeler*, Professor W. M., Harvard University, 101 Chestnut St., Boston, Mass., U. S. A.
684. *Whetzel*, Professor H. H., New York State College of Agriculture, Ithaca, N. Y., U. S. A.
685. *White*, G. F., U. S. Department of Agriculture, Washington, D. C., U. S. A.
686. *Wilbur*, D. A., Ohio State University, Columbus, Ohio, U. S. A.

687. *Wilcox,* Clara L., 1402 Pacific St., Brooklyn, N. Y., U. S. A.
688. *Wild,* W., 249 Walnut St., East Aurora, N. Y., U. S. A.
689. *Wild,* Mrs. W. (Associate).
690. *Wilder,* M. C., Brown University, Providence, R. I., U. S. A.
691. *Williams* Jr., R. C., 4537 Pine St., Philadelphia, Pa., U. S. A.
692. *Williams,* Professor S. H., University of Pittsburgh, Pittsburgh, Pa., U. S. A.
693. *Willis,* W. J., 24824 89th Ave., Queen's Village, N. Y., U. S. A.
694. Wolcott, G. N., Barneveld, New York, U. S. A.
695. *Wolf,* L. E., New York State College of Agriculture, Ithaca, N. Y., U. S. A.
696. Wood, F. C., Bureau of Entomology, Nanking, Kiangsu Province, China.
697. *Worthley,* L. H., U. S. Department of Agriculture, Corn Borer Control, Malden, Mass., U. S. A.
698. *Wright,* Professor A. H., Cornell University, Ithaca, N. Y., U. S. A.
699. *Wright,* Mrs. A. H. (Associate).
700. *Yothers,* W. W., U. S. Bureau of Entomology, Orlando, Fla., U. S. A.
701. *Yothers,* Mrs. W. W. (Associate).
702. *Young,* Professor B. P., Cornell University, Ithaca, N. Y., U. S. A.
703. *Zaitzev,* Professor P. A., Polytechnical Institute of Tiflis, U. S. S. R.
704. Zerkowitz, A., 5, rue Remy de Gourmont, Paris, XIXe, France.
*705. Zoological Museum, Tring (Herts.), England.
706. Zoologisches Museum, Steintorwall, Hamburg I, Germany.

Members (Hon. and Ord.) . .	610
Associates	107
Total	717

Attendance at Fourth Congress 611.

Foreign Membership: 229.

Names of the 134 members and associates present at the Congress printed in *italics*.

1. Argentina
   - *Bollini*, A. C.
   - *Bollini*, Mrs. A. C.
   - Bruch, C.
   - Dallas, E. D.
2. Armenia
   - *Dakessian*, V. S.
3. Australia
   - Girault, A A.
   - *Gurney*, W. C.
   - *Holdaway*, F. G.
   - Jarvis, E.
   - *Tillyard*, R. J.
4. Austria
   - Handlirsch, A.
   - *Heikertinger*, F.
5. Belgium
   - *Ball*, A.
   - Ministère de l'Agriculture
   - Ministère des Colonies
   - École de Médicine Tropicale
   - Institut Agricole de Gembloux
   - Musée du Congo Belge
   - Musée Forestier
   - Musée Royal d'Histoire Naturelle
   - *d'Orchymont*, A.
   - *d'Orchymont*, Mlle. L.
   - Société Entomologique de Belgique
6. British India
   - Agricultural Institute, Pusa
   - Barns, W.
   - *Bhosale*, Y. P.
   - Fletcher, T. B.
   - Forest Research Institute, Dehra Dun
   - Indian Museum
   - Kannan, K. K.
7. British West Indies
   - Ballou, H.
   - Cleare, L. D.
8. Bulgaria
   - *Tschorbadjieff*, P.
9. Canada
   - *Baker*, A. W.
   - *Brittain*, W. H.
   - *Brown*, W. J.
   - *Crawford*, H. G.
   - *Detwiler*, J. D.
   - *Duporte*, E. M.
   - *Ford*, Norma
   - *Fowler*, W. A.
   - *Gibson*, A.
   - *Hadwen*, S.
   - *Hinman*, E. H.
   - *Kelsall*, A.
   - *King*, K. M.
   - *Lochhead*, A. G.
   - *Maheux*, G.
   - *McLaine*, L. S.
   - *Mitchener*, A. V.
   - *Prince*, A. G.
   - *Ross*, W. R.
   - *Spencer*, G. J.
   - *Thompson*, C. S.
   - *Walley*, G. S.
10. Chile
    - *Graf*, A.
11. China
    - Chang, H. S.
    - *Faust*, E. C.
    - Jung, G. P.
    - *Wang*, C. C.
    - Wood, F. C.
12. Cuba
    - *Van Dine*, D. L.

13. Czechoslovakia
Cebeova, M.
Hetschko, A.
Rambousek, F.
Šámal, J.
14. Denmark
Henriksen, K. L.
Kryger, J. P.
Thomsen, M.
15. Egypt
Efflatoun Bey, H. C.
16. Finland
Saalas, U.
Saalas, Mrs. U.
Vappula, N. A.
17. France
Bouvier, E.-L.
Bugnion, E.
Carié, P.
Deville, J. Ste.-Claire
Janet, Chas.
Jeannel, R.
Lathy, P.
Regnier, R.
Regnier, Mme. R.
Trouvelot, B.
Vayssière, P.
Zerkowitz, A.
18. Germany
Baunacke, K. W.
Dingler, M.
Eidmann, H. A.
Enderlein, G.
Entomologisches Museum der K.-W.-Ges.
Horn, W.
Kleine, R.
Köhler, K. F.
Kolbe, H.
Martini, E.
Prell, H.
Rosen, K. von
Schwartz, M.
Skwarra, Frl. E.
Stadtbibliothek, Hamburg
Stellwaag, F.
Zoologisches Museum, Hamburg.
19. Great Britain
Adkin, R.
Barnes, T. C.
Bisset, G. B.
Burr, M.
Collin, J. E.
Committee of Civil Research, London
Eastham, L. E. S.
Edwards, F. W.
Edwards, Mrs. F. W.
Entomological Society of London
Foreign Office
Fryer, J. C. F.
Green, E. E.
Hose, Chas.
Hose, Mrs. Chas.
Imms, A. D.
Imperial Bureau of Entomology
Jackson, Miss D. J.
Jordan, K.
Jordan, Miss H.
Jordan, Miss A.
Levick, J.
Literary and Philosophical Society, Newcastle-upon-Tyne
MacDougall, R. S.
Ministry of Agriculture, Belfast
Ministry of Agriculture and Fisheries, London
Northamptonshire Natural History Society and Field Club
Poulton, E. B.
Prout, L. B.
Riley, N. D.
Richards, O. W.
Rothschild, Lord
Talbot, G.
Tams, W. H. T.
Turner, H. J.
Waterston, J.
Wilson, G. Fox
Zoological Museum, Tring.
20. Greece
(*Herrick*, G. W., delegate)
Sanninos, A.
21. Guatemala
Novella, T. M.
22. Hawaii
Muir, F. A.
Mumford, E. P.
Swezey, O. H.
Swezey, Mrs. O.

23. Hungary
Entomological Society
Horváth, G.
Jablonowski, J.
Magyar Nemzeti Museum
Streda, R.

24. Ireland
Carroll, J.

25. Italy
Gestro, R.
Gridelli, E.
R. Instituto Superiore Agrario, Portici
Silvestri, F.
Verity, R.

26. Java
Hazelhoff, E. H.
Leefmans, S.

27. Mexiko
Dampf, A.

28. The Netherlands
Corporaal, J. B.
Everts, E.
Klynstra, B. A.
MacGillavry, D.
Meijere, J. C. H. de
Oudemans, J. Th.
Peters, L. A. H.
Peters, Mrs. L. A. H.
Roepke, W.
Uyttenboogaart, D. L.
Valck Lucassen, F. T.

29. New Zealand
Marsden, E.

30. Nippon
Esaki, T.
Inomata, S.
Kuwayama, S.
Marutsen Co.
Matsumura, S.
Shiraki, S.
Watanabe, L.

31. Norway,
Natvig, L. R.

32. Palestine
Bodenheimer, F.

33. Peru
Estación Experimental Agricola

34. Poland
Bledowsky, R.
Jaczewski, T.

35. Porto Rico
Danforth, S. T.
Muller, A. S.
Nolla, J.

36. Roumania
Ciurea, J.
Knechtel, W.

37. Russia
Alpatov, W. W.
Adrianov, P. I.
Bogdanoff-Katjkov, N. N
Borodin, D. N.
Dobzhansky, T.
Filipjev, I. N.
Kashkarov, D.
Martynov, A. B.
Nikolsky, V.
Parfentjev, I. A.
Rimsky-Korsakov, M. I.
Semenov-Tjan-Shansky, A.
Zaitzev, P.

38. South Africa
Akerman, C.
Dept. of Agriculture, Pietermaritzburg
Dept. of Agriculture, Pretoria
Government of Natal
Pettey, F. W.
Pettey, Mrs. F. W.
Skaife, S. F.
Transvaal Museum

39. Spain
Bolivar, I.
Bolivar y Pieltain, C.
Ceballos, G.
Navás, L.
Nonell y Comas, J.
Silvela, F.
Torres, D. D. de
Academia de Sciencias Naturales, Zaragoza

40. Sudan
King, H. H.

41. Sweden
Kemner, N. A.
Trägårdh, I.
Trägårdh, Mrs. I.

42. Switzerland
Biedermann, R.
Escher-Kündig, J.
Forel, A.
Handschin, A.
Imhof, O. E.
Schulthess, A. von
43. Venezuela
Rincones, P. R.

Official Delegates

Argentina
Department of Agriculture
A. C. Bollini, Consul General, New York City
Australia
The Commonwealth
Dr. Robin J. Tillyard, Canberra
Austria
Zoologisch-Botanische Gesellschaft, Wien
F. Heikertinger
Belgium
The Government
A. d'Orchymont
Musée Royal d'Histoire Naturelle de Belgique, Bruxelles
Antoine Ball
Société entomologique de Belgique, Bruxelles
A. d'Orchymont
Antoine Ball
Bulgaria
Station agronomique de l'État, Sofia
Dr. P. Tschorbadjieff
Société Entomologique de Bulgarie
Dr. P. Tschorbadjieff
Ministère de l'Agriculture et des Domaines
Dr. P. Tschorbadjieff
Dominion of Canada
Department of Agriculture, Entomological Branch, Ottawa, Ontario
Arthur Gibson
McGill University, Macdonald College, Quebec
Professor W. H. Brittain
University of British Columbia, Vancouver, B. C.
Professor G. J. Spencer
University ot Western Ontario
Dr. J. D. Detwiler
University of Toronto, Toronto, Ontario
Dr. Norma Ford
Laval University, Quebec
Georges Maheux
Entomological Society of Ontario
Professor A. W. Baker
Professor W. H. Brittain
Arthur Gibson
Quebec Society for the Protection of Plants
E. Melville Du Porte
Chile
The Government
Alberto Graf
Sociedad agronomica de Chile, Santiago
Alberto Grat
China
Ministry of Agriculture and Research
C. C. Wang, Nanking
Cuba
Tropical Plant Research Foundation, Cuba Sugar Club Experiment Station, Central Baraguá, Province of Camagüey
D. L. Van Dine
Czechoslovakia
Ministry of Agriculture
Dr. Fr. Rambousek
Museum Regni Bohemiae Pragai
Dr. Fr. Rambousek

Societas Entomologica Czechoslovakiae, Praha
Dr. Fr. Rambousek
Dr. Jaromir Šámal
Académie Tchécoslovaque d'Agriculture, Prague
Dr. Fr. Rambousek

Denmark
Universitetet Zoologisk Museum, København
Kai L. Henriksen
Kgl. Veterinär- og Landbohøjskole, København
Mathias Thomsen
Entomologisk Forening, København
J. P. Kryger

Egypt
Ministry of Agriculture, Cairo
Dr. Hassan C. Efflatoun Bey
Société royale Entomologique d'Egypte, Cairo
Dr. Hassan C. Efflatoun Bey

Finland
The Government
Dr. Uunio Saalas, Helsinki
Societas Zoolog.-Botanicae Fennicae, Vanamo
Dr. Uunio Saalas, Helsinki
Agricultural Experiment Station, Tikkurila,
Niilo A. Vappula

France
Ministère d'Agriculture, Paris
Dr. Bernard Trouvelot
Dr. P. Vayssière
Société Entomologique de France
Dr. René Jeannel
Dr. Paul Vayssière
Société Biogéographia
Dr. René Jeannel
Dr. Paul Vayssière
Le Vivarium, Muséum National d'Histoire Naturelle, Paris
Dr. René Jeannel
Ministère de l'Instruction Publique, Paris
Professeur E.-L. Bouvier
Institut des Recherches Agronomiques, Rouen
Dr. Robert Regnier

Germany
Reichsministerium des Innern, einschliesslich des Reichsgesundheitsamtes
Dr. Martin Schwartz
Reichsministerium für Ernährung und Landwirtschaft, einschliesslich der Biologischen Reichsanstalt für Land- und Forstwirtschaft
Dr. Martin Schwartz
Preußisches Kultus-Ministerium, Berlin
Frl. Dr. Elisabeth Skwarra, Königsberg
Staatliche Landwirtschaftliche Versuchsanstalt, Dresden
Professor Dr. Baunacke
Staatliche Lehr- und Versuchsanstalt für Wein- und Obstbau, Neustadt, a. d. Hdt.
Professor Dr. F. Stellwaag
Forstinstitut der Universität, Giessen
Professor Dr. Max Dingler
Deutsches Entomologisches Institut der Kaiser Wilhelm-Gesellschaft, Berlin-Dahlem
Dr. Walther Horn
Institut für angewandte Zoologie der Universität, München
Professor Dr. H. A. Eidmann
Institut für Schiffs- und Tropenkrankheiten, Hamburg
Professor Dr. E. Martini
Deutsche Gesellschaft für angewandte Entomologie
Professor Dr. F. Stellwaag

Great Britain
Ministry of Agriculture and Fisheries, London
J. C. F. Fryer
Dr. A. D. Imms
N. D. Riley
Rothamsted Experimental Station, Harpenden, Herts.
Dr. A. D. Imms

Cambridge University
L. E. S. Eastham
British Museum of Natural History, London
F. W. Edwards
N. D. Riley
W. H. Tams
Dr. James Waterston
The Hill Museum, Witley, Surrey,
G. Talbot
Zoological Museum, Tring, Herts.,
Dr. Karl Jordan
Association of Economic Entomologist, London
Dr. A. D. Imms
British Empire Forestry Association, London
Dr. Charles Hose
Mrs. Charles Hose
Entomological Society of London,
James E. Collin
N. D. Riley
Linnean Society of London,
Dr. A. D. Imms
Royal Horticultural Society, London,
G. Fox Wilson
The Apis Club
Professor E. F. Phillips, Ithaca.

Greece
The Government
Professor Glenn W. Herrick, Ithaca

Guatemala
The Government
M. J. Novella, Consul General in New York City

Hungary
Magyar Entomologiai Társaság, Budapest
Rev. Dr. R. Streda

Ireland
National University of Ireland, Dublin
John Carroll

Italy
Institut International d'Agriculture, Roma
Dr. L. O. Howard, Washington, D. C.
Ministry of National Economy
Professor F. Silvestri
Ministry of the Interior
Professor F. Silvestry
Società entomologica Italiana, Genova
Dr. E. Gridelli
Museo Civico di Storia Naturale, Genova
Dr. E. Gridelli

Mexico
Oficina Federal de Defensa Agricola, San Jacinto, D. F.
Professor Dr. Alfons Dampf

The Netherlands
The Government
L.A.H. Peters, Washington, D. C.
Professor W. Roepke, Wageningen
J. B. Corporaal, Amsterdam
Zoölogisch Museum, Amsterdam
J. B. Corporaal
Koninklijk Zoologisch Genootschap Natura Artis Magistra, Amsterdam
J. B. Corporaal
Nederlandsche Entomologische Vereeniging, Amsterdam
J. B. Corporaal
Landbouwhoogeschool, Wageningen
Professor W. Roepke

Nippon (Japan)
Ministry of Agriculture and Forestry, Tokyo
Professor Shujiro Inomata, Tottori
Board of Agriculture
Professor Shujiro Inomata, Tottori
Board of Sericulture
Dr. Kanji Watanabe, Tokyo
Ministry of Education, Tokyo
Professor Shujiro Inomata, Tottori

Norway
The Government
Leif R. Natvig
Universitas Regia Fredericiana, Oslo
Leif R. Natvig

Poland
Ministry of Agriculture
Professor Dr. R. Bledowski

Université libre de Pologne, Varsovie
Professor Dr. R. Bledowski

Rumania
Ministry of Agriculture
W. Knechtel, Bucharest

Russia (U. S. S. R.)
Department of Agriculture, Moscow
Paul I. Adrianov
University of Moscow
Professor I. A. Parfentiev
Academy of Sciences, Leningrad
Dr. A. B. Martynov
Forest Institute, University of Leningrad
Professor M. N. Rimsky-Korsakov
Institute for Applied Zoology and Phytopathology, Leningrad
N. N. Bogdanov-Katjkov
Polytechnic Institute, Tiflis
Professor A. Zaitzev
State Institute of Experimental Agronomy, Bureau of Applied Entomology, Leningrad
Dr. Iv. Nik. Filipjev

Spain
The Government
Don Fernando Silvela, Washington, D. C.
Don Demetrio D. de Torres, Madrid
Don Jaime Nonell y Comas
Museo Nacional, Madrid
Dr. C. Bolivar y Pieltain
Real Academia de Ciencias, Madrid
Dr. C. Bolivar y Pieltain
Don Gonzalo de Ceballos Fernández de Córdoba
Instituto Nacional de Investigaciones Agronomicas, Madrid
Don Demetrio D. de Torres
Estación de Patologia Vegetal de Barcelona
Don Jaime Nonell y Comas
Estación Central de Patologia Vegetal de Madrid
Don Demetrio D. de Torres
Academia de Ciencias Exactas, Fisico-Quimicas y Naturales de Zaragoza
R. P. Longinos Navás, S. J.*)
Collegio de Salvador, Zaragoza
R. P. Longinos Navas, S. J.

Sweden
The Government
Professor I. Trägårdh
Experimentalfältet, Stockholm
Professor I. Trägårdh
Entomologiska Föreningen, Stockholm
Dr. N. A. Kemner, Experimentalfältet

The United States of America
National Academy of Sciences, Washington, D. C.
Dr. L. O. Howard
Professor W. M. Wheeler
National Research Council, Washington, D. C.
Professor William A. Riley, Minneapolis, Minnesota
Bureau of Entomology, Washington, D. C.
Dr. C. L. Marlatt
Dr. L. O. Howard
Bureau of Animal Industry, Washington, D. C.
Dr. M. C. Hall
Public Health Service, Washington, D. C.
Dr. Edward Francis
Dr. R. R. Parker
Dr. C. W. Stiles

Alabama
Alabama Polytechnic Institute, Auburn
Professor Henry G. Good

Arizona
University of Arizona, Tucson
Professor C. T. Vorhies

California
California Academy of Sciences, San Francisco
Professor E. P. Van Duzee

*) Could not attend the Congress.

University of California, Berkeley
Professor W. B. Herms
Professor E. C. Van Dyke
Department of Agriculture, Sacramento
David B. Mackie

Colorado
Colorado College, Colorado Springs
Dr. M. C. Hall, Washington, D. C.
W. C. Senning, Ithaca, New York
R. P. Hunter, Ithaca, New York
Colorado Agricultural College, Fort Collins
Professor C. M. List,

Connecticut
Connecticut Agricultural College, Storrs
Professor George H. Lamson, Jr.
Agricultural Experiment Station, New Haven
Dr. W. E. Britton

Delaware
Agricultural Experiment Station, University of Delaware, Newark
Professor H. L. Dozier

District of Columbia
Biological Society of Washington
Dr. C. L. Marlatt
Dr. H. Morrison
T. E. Snyder

Florida
State Plant Board, Gainesville
Dr. E. D. Ball, Sanford

Hawaii
Experiment Station of the Hawaiian Sugar Planters' Association, Honolulu
O. H. Swezey
F. Muir
Entomological Survey of the Pacific Islands, Bishop Museum
Edward P. Mumford

Illinois
Illinois State Laboratory of Natural History, Urbana
Professor S. A. Forbes
Dr. T. Frison
Field Museum of Natural History
W. J. Gerhard

Indiana
Indiana Academy of Sciences, Indianapolis
Professor J. J. Davis, Lafayette

Iowa
Iowa Academy of Sciences, Des Moines
Professor H. H. Knight, Ames

Louisiana
Agricultural Experiment Station, Baton Rouge
Professor W. E. Hinds

Kansas
Kansas State Agricultural College, Manhattan
Professor George A. Dean
Professor R. L. Parker

Maryland
School of Hygiene, The Johns Hopkins University, Baltimore
Dr. F. M. Root
Agricultural Experiment Station, College Park
Dr. E. N. Cory

Massachusetts
Department of Tropical Medicine, Harvard Medical College, Harvard University, Boston
Dr. Joseph Bequaert
Wellesley College, Wellesley
Professor A. P. Morse
Smith College, Northampton
Professor H. M. Parshley
Mount Holyoke College, South Hadley
Professor Ann Morgan
American Academy of Arts and Sciences, Boston
Professor W. M. Wheeler
Peabody Museum, Salem
Professor A. P. Morse

Massachusetts Agricultural College, Amherst
Professor G. C. Crampton
Professor C. P. Alexander
Agricultural Experiment Station, Amherst
Professor Arthur I. Bourne

Michigan
State College of Agriculture and Applied Sciences, East Lansing
Professor L. G. Gentner
University of Michigan
Professor S. A. Graham

Minnesota
State Department of Agriculture, St. Paul
Professor A. G. Ruggles
University of Minnesota, Minneapolis
Professor William A. Riley
Professor Royal N. Chapman

Mississippi
College of Agriculture and Mechanic Arts, Agricultural College
Professor R. W. Harned

Missouri
University of Missouri, Columbia
Professor Leonard Haseman
State Plant Board, Columbia
Professor Leonard Haseman

Montana
Agricultural Experiment Station, Bozeman
Professor J. R. Parker

Nebraska
University of Nebraska, Lincoln
Professor Myron H. Swenk

New Hampshire
Dartmouth College, Hanover
Professor John H, Gerould

New Jersey
Rutgers University, New Brunswick
Professor T. J. Headlee

New York
Rochester Academy of Sciences, Rochester
Professor J. Douglas Hood
American Museum of Natural History, New York City
Dr. Frank E. Lutz
Boyce Thompson Institute for Plant Research, Yonkers
Albert Hartzell
New York State College of Agriculture, Ithaca
Professor James G. Needham
The Jugatae, Cornell University, Ithaca, New York
F. C. Fletcher
New York State Agricultural Experiment Station, Geneva
Professor P. J. Parrott
University of Rochester, Rochester
Professor J. Douglas Hood
St. Lawrence University, Canton
Professor J. L. Buys
College, City of New York
Professor A. L. Melander
New York State Museum, Albany
Dr. Robert D. Glasgow
Vassar College, Poughkeepsie
Professor Aaron L. Treadwell
Wells College, Aurora
Professor Ida L. Reveley
Brooklyn Museum, Brooklyn
George P. Engelhardt
Syracuse University, Syrakuse
M. W. Blackman
Staten Island Institute of Arts and Sciences, Staten Island
C. W. Leng

North Carolina
Department of Agriculture, Raleigh
Dr. R. W. Leiby

North Dakota
Agricultural College and Experiment Station, Fargo
Professor J. Alex Munro
University of North Dakota
Professor. G. C. Wheeler, Grand Forks

Ohio
Ohio Academy of Sciences
Professor Herbert Osborn

Ohio State University, Columbus
Professor Herbert Osborn
Agricultural Experiment Station, Wooster
Dr. J. S. Houser
Dr. L. L. Huber
C. R. Cutright
Oberlin University, Oberlin
Professor L. H. MacDaniels, Ithaca, New York
Capital University, Columbus
Professor Robert N. Geist
Oregon
State Agricultural College, Corvallis
Professor Don C. Mote
Pennsylvania
Pennsylvania State College, State College
Professor E. H. Dunham
Dr. V. R. Haber
University of Pittsburgh, Pittsburgh
Professor A. E. Emerson
Carnegie Museum, Pittsburgh
Dr. A. Avinoff
Dr. Hugo Kahl
Dr. W. J. Holland
Department of Agriculture, Bureau of Plant Industry, Harrisburg
Thomas L. Guyton
Joseph N. Knull
Fordham University, New York City
Professor Jos. Assmuth
American Entomological Society, Philadelphia
Professor Philip P. Calvert
Roswell C. Williams, Jr.
Frank Morton Jones
Porto Rico
University of Porto Rico, Rio Piedras
Dr. S. T. Danforth
A. S. Miller
Rhode Island
Brown University, Providence
Dr. Magel Wilder
Texas
Agricultural and Mechanical College, College Station
Professor S. W. Bilsing
Rice Institute, Houston
Professor M. A. Stewart
Utah
Brigham Young University, Provo
Dr. Vasco M. Tanner
Washington
State College of Washington, Pullman
Professor R. L. Webster
Union of South Africa
Department of Agriculture
Dr. F. W. Pettey, Elsenburg
Venezuela
P. R. Rincones, Consul General, New York City
New Zealand
The Government
Dr. E. Marsden

PROGRAM

SATURDAY, AUGUST 11

Registration, Willard Straight Hall.

SUNDAY, AUGUST 12

Registration, Willard Straight Hall.
9:00 a. m. Excursion, Buttermilk Creek (see page 9).
1:30 p. m. Excursion, Lick Brook (see page 9).
3:00 p. m. Motion pictures, University Theater, Willard Straight Hall.
4:00 p. m. Tea, Willard Straight Hall.
8:00 p. m. Informal gathering, Willard Straight Hall.

MONDAY, AUGUST 13

Registration, Willard Straight Hall.

9:00 a. m. **General Session**

(Bailey Hall)

Chairman: Dr. L. O. Howard, Bureau of Entomology, Washington, D. C., President of the Fourth International Congress of Entomology.

Vice-Chairman: Professor William Morton Wheeler, Bussey Institution, Harvard University, Forest Hills, Massachusetts, Vice-President of the Fourth International Congress of Entomology.

Vice-Chairman: Professor James G. Needham, Cornell University, Ithaca, New York, Vice-President of the Fourth International Congress of Entomology.

Secretary: Professor O. A. Johannsen, Cornell University, Ithaca, New York.

Addresses of Welcome, *Dean W. A. Hammond* of the University Faculty and *Dean Albert R. Mann* of the New York State College of Agriculture, Cornell University, Ithaca, New York.

Address of the President of the Fourth International Congress of Entomology, *Dr. L. O. Howard.*

Le Peuplement de l'Amérique du Nord par les Trechinae, *René G. Jeannel*, Director du Vivarium, Muséum national d'Histoire Naturelle, Paris, France.

Fauna of the soil in Swedish forests, *I. Trägårdh*, Experimentalfältet, Stockholm, Sweden.

Problems of distribution and variation of North American fleas, *Karl Jordan*, Zoological Museum, Tring, Herts., England.

Communication of the Permanent Secretary of the Executive Committee, *Karl Jordan*.

2:00 p. m. Meetings of Sections.

Nomenclature and Bibliography

(Main Lecture Room, Baker Laboratory)

Chairman: Dr. E. Gridelli, Museo Civico di Storia Naturali, Genova, Italy.

Vice-Chairman: Dr. J. M. Aldrich, United States National Museum, Washington, D. C.

Secretary: Dr. P. P. Babiy, Cornell University, Ithaca, New York.

The future of zoological nomenclature, *Charles W. Stiles*, Secretary of the International Commission on Zoological Nomenclature, Public Health Service, Washington, D. C.

FORUM ON NOMENCLATURE

An informal discussion of problems of nomenclature affecting entomology. It is hoped that all attending will take part. The names are listed of persons, in addition to discussion leaders, who have indicated their intention of taking part in the discussions.

The Theory of Nomenclature: Discussion leaders: *C. H. Kennedy*, Ohio State University, Columbus, Ohio; *F. Muir, G. Talbot, Karl Jordan, F. Silvestri*.

Family Names: Discussion leaders: *A. L. Melander*, College of the City of New York, New York City; *G. F. Ferris, F. Muir*.

Other Problems of Nomenclature:

1. Report of the British National Committee on Entomological Nomenclature.
2. Nomenclature of groups of lower rank than species, *Roger Verity*, Firenze.

Ecology

(Room 207, Baker Laboratory)

Chairman: Dr. C. C. Adams, Director, State Museum, Albany, New York.

Secretary: Professor James G. Needham, Cornell University, Ithaca, New York.

The measurement of the effect of ecological factors, *Royal N. Chapman*, University Farm, St. Paul, Minnesota.

On the relation between the color of silk worms and the environment, *Kanji Watanabe*, Department of Agriculture, Tokyo, Nippon.

The Black Locust Tree Scale, *Lecanium robiniarum* Douglas, and the European Corn Borer, *Pyrausta nubilalis* Schiff., a Biological Parallel, *J. Jablonowski*, Entomological Station, Budapest, Hungary.

Medical and Veterinary Entomology

Chairman: Professor W. A. Riley, University of Minnesota, Minneapolis, Minnesota.

Secretary: Professor Robert Matheson, Cornell University, Ithaca, New York.

Arthropods as intermediate hosts of Helminths, *M. C. Hall,* Bureau of Animal Industry, Washington, D. C.

Arthropods in the transmission of Tularaemia, *Edward Francis,* Public Health Service, Washington, D. C.

Rocky Mountain spotted fever, *R. R. Parker,* Field Laboratory, Public Health Service, Hamilton, Montana.

Apiculture

4:30 p. m. Demonstration of artificial insemination of queenbees, *Lloyd R. Watson,* Alfred, New York, in Amphitheatre, Stimson Hall.

Economic Entomology

Cereal and Truck Crop Insects

(Room 107, Baker Laboratory)

Chairman: Professor J. J. Davis, Purdue University, Lafayette, Indiana.

Vice-Chairman: Professor R. L. Webster, State College of Washington, Pullman, Washington.

Secretary: Professor C. R. Crosby, Cornell University, Ithaca, New York.

The problem of controlling underground insect pests, *J. W. McColloch* and *W. P. Hayes,* Kansas State Agricultural College, Manhattan, Kansas.

The value of quantitative methods of investigation of field crop insects with special reference to work with wireworms and cutworms, *K. M. King,* Branch Laboratory, Department of Agriculture, Entomological Branch, Saskatoon, Saskatchewan.

Local conditions as influencing recommendations for the control of sugar cane insects, *T. E. Holloway,* Sugar Cane and Rice Insects Field Laboratory, Bureau of Entomology, New Orleans, Louisiana.

Control of Acrididae in U. S. S. R., *I. A. Parfentiev,* Scientific Research Laboratory of Narkomzem, Moscow, U. S. S. R.

Parasites of the genus Diatraea, *D. L. Van Dine,* Tropical Plant Research Foundation, Cuba Sugar Club Experiment Station, Central Baraguá, Province of Camagüey, Cuba.

Citrus Fruit Insects

(Roeckefeller Hall, Room A)

Chairman: Dr. F. W. Pettey, Department of Agriculture, Elsenburg, South Africa.

Vice-Chairman: Dr. A. C. Baker, U. S. Bureau of Entomology, Washington, D. C.

Secretary: Professor P. J. Parrott, New York Agricultural Experiment Station, Geneva, New York.

The fumigation of citrus trees, *H. J. Quayle,* Citrus Experiment Station and Graduate School of Tropical Agriculture, Riverside, California.

Oil sprays for citrus insects: Their history, uses and present status, *W. W. Yothers* and *O. C. McBride,* Citrus Sub-Station, Bureau of Entomology, Orlando, Florida.

Biological control of insect pests of citrus fruits, *Harry S. Smith,* Citrus Experiment Station and Graduate School of Tropical Agriculture, Riverside, California.

Insect problems of the citrus industry of Australia, *W. N. Gurney,* Entomologist, Queensland government, New South Wales.

3:00 p. m. Excursion, Enfield Gorge (see pages 10 and 13).
4:00 p. m. Tea, Willard Straight Hall.
4:00 p. m. Excursion, Fall Creek Gorge (see page 10).
5:00 p. m. Excursion, Fall Creek Gorge (see page 10).
8:00 p. m. Smoker, Willard Straight Hall (see page 3).
9:00 p. m. Summer Theater plays (see page 3).

TUESDAY, AUGUST 14

General Session

9:00 a. m. (Bailey Hall)

Chairman: Dr. W. J. Holland, Carnegie Museum, Pittsburgh, Pennsylvania.

Vice-Chairman: Dr. N. A. Kemner, Experimentalfältet, Sweden.

Secretary: Professor O. A. Johannsen, Cornell University, Ithaca, New York.

Saturnides américains, *E.-L. Bouvier,* Muséum National d'Histoire Naturelle, Paris, France.

Seuchen und Klima vom Standpunkt des Entomologen, *Erich Martini,* Institut für Schiffs- und Tropenkrankheiten, Hamburg, Germany.

On the splitting influence of the increase of entomological knowledge and the enigma of species, *Walther Horn,* Deutsches Entomologisches Institut der Kaiser Wilhelm-Gesellschaft, Berlin-Dahlem, Germany.

The relation of taxonomy to other branches of entomology, *Filippo Silvestri,* R. Istituto superiore agrario, Portici, Napoli, Italy.

A neotropical myrmecophyte *(Cordia alliodra)* and its tenants, *William Morton Wheeler,* Bussey Institution, Harvard University, Forest Hills, Massachusetts.

12:15 p. m. Official photograph of Congress, North of State Drill Hall.

2:00 p. m. Meetings of Sections.

Systematic Entomology and Zoogeography

(Main Lecture Room, Baker Laboratory)

Chairman: Dr. Candido Bolivar y Pieltain, Jefe de la Sección de Entomologia del Museo Nacional, Professor en la Universidad de Madrid, Madrid, Spain.

Vice-Chairman: José R. de la Torre-Bueno, New York City.

Secretary: Professor J. D. Hood, Rochester, N. Y.

The regional museum and one of its problems, *E. P. Van Duzee,* California Academy of Sciences, San Francisco, California.

Observations sur quelques coccides, *P. Vayssière,* Directeur-adjoint de la Station Entomologique, Paris, France.

Remarks on the keys of genera of European chalcid flies, *J. P. Kryger*, Gentofte, Denmark.

Remarks on morphology and geographical distribution of Neohydrophilus, *Armand d'Orchymont*, Bruxelles, Belgium.

A comparison of the systems of nomenclature that have been applied to the radial field of the wing in the Diptera, *C. P. Alexander*, Amherst, Massachusetts.

Nomenclature and Bibliography

(Room 207, Baker Laboratory)

Chairman: Dr. J. Waterston, British Museum, London, England.
Secretary: Dr. P. P. Babiy, Cornell University, Ithaca, New York.

A protest against the use of abbrevations ín original descriptions, *J. E. Collin*, President of the Entomological Society of London, Newmarket, England.

Sur la désignation des génotypes, *René G. Jeannel*, Directeur du Vivarium du Muséum d'Histoire Naturelle, Paris, France, et Professeur de Biologie générale de l'Université de Cluj, Roumania.

Das Kontinuitätsprinzip in der Nomenklatur, *F. Heikertinger*, Zoologisch-Botanische Gesellschaft, Wien, Austria.

Morphology, Physiology, Embryology and Genetics

(Room 177, Baker Laboratory)

Chairman: Dr. A. D. Imms, Rothamsted Experimental Station, England.
Vice-Chairman: Professor Dr. R. Bledowsky, Université libre de Pologne, Varsovie, Poland.
Secretary: Professor O. A. Johannsen, Cornell University, Ithaca, New York.

Some new anatomical observations bearing on the interrelationships of Arthropoda, *R. E. Snodgrass*, Bureau of Entomology, Washington, D. C.

Segmentation of the Arthropod head, *K. L. Henriksen*, Universitatets Zoologiske Museum, København, Denmark.

Über den Laut-Apparat der Flöhe, *Günther Enderlein*, Zoologisches Museum der Universität Berlin, Germany.

The Postembryological Development of Japyx, *F. Silvestri*, R. Instituto superiore agrario, Portici, Italy.

Medical and Veterinary Entomology

(Room 7, Baker Laboratory)

Chairman: Dr. W. E. Britton, Agricultural Experiment Station, New Haven, Connecticut.
Secretary: Professor Robert Matheson, Cornell University, Ithaca, New York.

The insect carrier of *Onchocerca volvulus* in Liberia, *Joseph Bequaert*, Harvard University Medical School, Boston, Massachusetts.

Some poisonous arthropods of North and Central America, *W. J. Baerg*, University of Arkansas, Fayetteville, Arkansas.

Environmental factors and mosquito breeding, *Willem Rudolfs*, University of New Jersey, New Brunswick, New Jersey.

Anopheline investigations in California, *W. B. Herms*, University of California, Berkeley, California.

Beeinflussung der Farbe von Mücken und ihren Larven, *E. Martini*, Institut für Schiffs- und Tropenkrankheiten, Hamburg, Germany.

Apiculture

(Room 377, Baker Laboratory)

Chairman: Dr. S. H. Skaife, Department of Education, Capetown, Union of South Africa.

Secretary: Professor E. F. Phillips, Cornell University, Ithaca, New York.

Variations in honeybees from the theoretical and practical points of view, *W. W. Alpatov*, University of Moscow, Moscow, U. S. S. R.

Reactions of light in honeybees, *Lloyd M. Bertkolf*, The Johns Hopkins University, Baltimore, Maryland.

Sugar metabolism in honeybee larvae, *Ethel Ronzoni* and *George H. Bishop*, Washington University School of Medicine, St. Louis, Missouri.

Effect of weather factors upon the flight activities of the honeybee, *Jas. I. Hambleton*, Bureau of Entomology, Washington, D. C.

Forest Insects

(Rockefeller Hall, Room B)

Chairman: Dr. F. C. Craighead, Bureau of Entomology, Washington, D. C.

Vice-Chairman: Professor J. S. Houser, Ohio Agricultural Experiment Station, Wooster, Ohio.

Secretary: Prof. Glenn W. Herrick, Cornell University, Ithaca, New York.

Über die Anwendung der Linien-Abschätzung bei der Frequenzbestimmung von Forstinsekten, *Uunio Saalas*, Universitaat Helsinki, Suomi, Finland.

Termites modify building codes, *T. E. Snyder*, Bureau of Entomology, Washington, D. C.

The control of imported tree-defoliating insects, *A. F. Burgess*, Gypsy Moth Laboratory, Bureau of Entomology, Melrose Highlands, Massachusetts.

Economic Entomology

Cereal and Truck Crop Insects

(Room 107, Baker Laboratory)

Chairman: Dr. Walter H. Larrimer, Bureau of Entomology, Washington, D. C.

Vice-Chairman: Professor Leonard Haseman, University of Missouri, Columbia, Missouri.

Secretary: Professor C. R. Crosby, Cornell University, Ithaca, New York.

The problem of biological control of insects in Hawaii, *F. Muir*, Experiment Station of the Hawaiian Sugar Planters Association, Honolulu, T. H.

Biological control of a sugar cane aphid by transferring its native parasite from the old to the young fields, *E. H. Hazelhoff*, Proefstation voor de Java-Suikerindustrie, Pasoeroean, Java.

Can we increase the usefulness of the egg parasite *Trichogramma minutum?*, *W. E. Hinds*, Agricultural Experiment Station, Baton Rouge, Louisiana.

Weather and the non-burning of trash in borer control in Porto Rico, *George N. Wolcott*, Peru. (Read by T. E. Holloway, New Orleans, La.)

Present status of certain insect pests under biological control in Hawaii, *O. H. Swezey*, Experiment Station of the Hawaiian Sugar Planters' Association, Honolulu, T. H.

Atmospheric evaporation in relation to Mexican bean beetle abundance: a field study, *N. F. Howard*, Mexican Bean Beetle Field Laboratory, Bureau of Entomology, Columbus, Ohio.

Parasites of the genus Diatraea, *D. L. Van Dine*, Tropical plant Research Foundation, Cuba Sugar Club Experiment Station, Central Baraguá, Province of Camgüey, Cuba.

Deciduous Fruit Insects

(Rockefeller Hall, Room A)

Chairman: Arthur Gibson, Department of Agriculture, Entomological Branch, Ottawa, Ontario, Dominion of Canada.

Vice-Chairman: Professor W. P. Flint, University of Illinois, Urbana, Illinois.

Secretary: Professor P. J. Parrott, New York Agricultural Experiment Station, Geneva, New York.

Injurious capsids of apple orchards in England, *J. C. F. Fryer*, Ministry of Agriculture and Forestry, London, England.

The fruit fly problems in Mexico, *Alfons Dampf*, Oficina Federal de Defensa Agricola, San Jacinto, D. F., Mexico.

Conchylis ambiguella and *Polychrosis botrana* im deutschen Weinbaugebiet, *Friedrich Stellwaag*, Staatliche Lehr- und Versuchsanstalt für Wein- und Obstbau, Neustadt, Germany.

The Japanese beetle: present status and latest developments, *Loren B. Smith*, Japanese and Asiatic Beetle Laboratory, Bureau of Entomology, Moorestown, New Jersey.

3:00 p. m. Motion pictures, University Theater, Willard Straight Hall.

4:00-4:30 p. m. Leave for picnic supper at Taughannock Falls (see pages 21 and 28).

6:00 p. m. Picnic supper on shore of Lake Cayuga.

WEDNESDAY, AUGUST 15

There are no sessions of the Congress scheduled for Ithaca on this day. All sessions of sections will be held at the New York State Agricultural Experiment Station at Geneva, New York. There is no general session of the Congress.

8:15-8:30 a. m. Special electric car service from the campus to the Lehigh Valley Railroad depot, Ithaca.

9:00 a. m. Special train leaves for Geneva (*8:00 a. m.* railroad or standard time)

10:00 a. m. Exhibition of apparatus and equipment for the control of insect pests and plant diseases on the grounds of the Experiment Station.

11:30 a. m. Summer meeting of the New York State Horticultural Society, Assemby Hall. *Thomas B. Byrd* of Virginia will address the meeting. Members of the Congress are cordially invited to attend.

12:30 p. m. Lunch may be obtained on the grounds.

2:00 p. m. Meetings of Sections.

Systematic Entomology and Zoogeography

(Library, Jordan Hall)

Chairman: Professor Dr. Bledowski, Université libre de Pologne à Varsovie, Poland.

Vice-Chairman: W. S. Blatchley, Indianapolis, Indiana.

Secretary: Chas. W. Leng, Staten Island Museum, N. Y.

The Permian fossil entomofauna of North Russia and its relation to the Kansan, *Andreas B. Martynow*, Zoological Museum, Academy of Sciences, Leningrad, U. S. S. R.

The geographical distribution of insects in Russia, *J. N. Filipjev*, State Institute of Experimental Agronomy, Bureau of Applied Entomology, Leningrad, U. S. S. R.

The influence which geographical distribution has had in the production of the insect fauna of North America, *E. C. Van Dyke*, University of California, Berkeley, California.

The origin of the Hawaiian Odonata Fauna and its evolution within the islands, *Clarence H. Kennedy*, Ohio State University, Columbus, Ohio.

An account of a collecting trip to Patagonia and southern Chile, *F. W. Edwards*, British Museum (Natural History), London, England.

Economic Entomology

Cereal and Truck Crop Insects

(Jordan Hall)

Chairman: Professor Myron H. Swenk, University of Nebraska, Lincoln, Nebraska.

Secretary: Professor C. R. Crosby, Cornell University, Ithaca, New York.

The control of root-eating Scarabaeid grubs in Queensland canefields, *Edmund Jarvis*, Bureau of Sugar Experiment Stations, Queensland, Australia.

Hessian fly control in the United States, *C. M. Packard*, Cereal and Forage Insects Field Laboratory, Bureau of Entomology, West Lafayette, Indiana.

The European corn borer, *Pyrausta nubilalis* Hübn., its history and status as a problem in the United States, *D. J. Caffrey*, European Corn Borer Field Laboratory, Bureau of Entomology, Arlington, Massachusetts.

The European corn borer, *Pyrausta nubilalis* Hübn., its history and status as a problem in Canada, *H. G. Crawford*, Department of Agriculture, Entomological Branch, Ottawa, Ontario, Dominion of Canada.

Experimental studies on the effect of "Kambara" earth upon the double cocoon formation of the silk worm, *S. Inomata*, College of Agriculture, Tottori, Nippon.

Some observations on the so-called corn borer in Japan, *Satoru Kuwayama*, Sapporo, Nippon.

Deciduous Fruit Insects
(Assembly Hall)

Chairman: Dr. E. D. Ball, State Plant Board, Sanford, Florida.

Vice-Chairman: Professor W. H. Brittain, Macdonald College, Quebec, Dominion of Canada.

Secretary: Professor P. J. Parrott, New York Agricultural Experiment Station, Geneva, New York.

Codling moth control and removal of lead arsenate from fruit in South Africa, *F. W. Pettey*, Department of Agriculture, Elsenburg, Union of South Africa.

The codling moth problem in America, *B. A. Porter*, Bureau of Entomology, Washington, D. C.

The status of present spray practices and prospects of improvement in control measures for the codling moth, *E. J. Newcomer*, Bureau of Entomology, Washington, D. C. [read by *A. L. Quaintance*].

The problem of arsenical residues: The situation in different apple-growing areas and results of investigations relative to the production of apples to meet market requirements, *Leroy Childs*, Hood River Branch Experiment Station, Hood River, Oregon.

The problem of arsenical residues: Importance of spray deposits from the standpoint of public health, *Harry A. Kuhn*, Chemical Warfare Service, Edgewater Arsenal, Edgewater, Maryland.

The mass production of *Trichogramma minutum* Riley, and observations on the natural and artificial parasitism of the codling moth egg, *Stanley E. Flanders*, Saticoy Walnut Growers' Association, Saticoy, California.

5:00 p. m. Members of the Congress will be guests of the Experiment Station staff at tea on the Station grounds.

7:30 p. m. Special train (Lehigh Valley Railroad) direct from the Station grounds to Ithaca (*6:30 p. m.* railroad or standard time), arriving about an hour later.

Events in Ithaca:

3:00-5:00 p. m. Motion pictures, University Theatre, Willard Straight Hall.

4:00 p. m. Tea, Willard Straight Hall.

8:00 p. m. Motion pictures, University Theatre, Willard Straight Hall.

THURSDAY, AUGUST 16

8:30 a. m. Excursion, Wild Flower Preserve (see page 10).

9:00 a. m. **General Session**
(Bailey Hall)

Chairman: Professor Filippo Silvestri, R. Istituto superiore agrario, Portici, Napoli, Italy.

Secretary: Professor O. A. Johannsen, Cornell University, Ithaca, New York.

Insect inhabitants of the upper air, *E. P. Felt*, Bartlett Research Laboratories, Stamford, Connecticut.

The mutual relations of museums of science and taxonomic specialists, *W. J. Holland*, Carnegie Museum, Pittsburgh, Pennsylvania.

Fresh-water-living Hymenopterous parasites in Russia, *M. N. Rimsky-Korsakov*, University, Leningrad, U. S. R. R.

Development of entomological science in Egypt, *Hassan C. Efflatoun Bey*, Meadi, Cairo, Egypt.

Restrictions enforced by the United States on entry of foreign plants and plant products for the purpose of excluding new and dangerous pests, *C. L. Marlatt*, Chief, Bureau of Entomology, Washington, D. C.

9:00 a. m. Excursion, Arnot Forest (see pages 24 and 29).

2:00 p. m. Meetings of Sections.

Systematic Entomology and Zoogeography

(Main Lecture Room, Baker Laboratory)

Chairman: Dr. Karl Jordan, Zoological Museum, Tring, Herts., England.

Vice-Charman: Professor A. P. Morse, Wellesley College, Wellesley, Massachusetts.

Secretary: Professor J. Chester Bradley, Cornell University, Ithaca, New York.

The future of insect taxonomy, *Walther Horn*, Deutsches Entomologisches Institut der Kaiser Wilhelm Gesellschaft, Berlin-Dahlem, Germany.

FORUM ON PROBLEMS OF TAXONOMY

An informal discussion of problems confronting the insect taxonomist. It is hoped that all persons attending will take part. The names of persons, in addition to discussion leaders, who have indicated their intention of taking part in the discussions, are listed.

Taxonomy and phylogenetic groups. Discussion leaders: *Philip P. Calvert*, University, of Pennsylvania, Philadelphia, Pennsylvania; *F. Muir*, *G. F. Ferris*, *Karl Jordan*, *A. Dampf*, *F. Silvestri*.

Catalogs. Discussion leaders: *Antoine J. Ball*, Muséum d'Histoire Naturelle à Bruxelles, Belgique, *F. Muir*, *E. T. Cresson Jr.*, *F. Silvestri*.

Types. Discussion leaders: *James Waterston*, British Museum (Natural History), London, England; *W. J. Holland*, Carnegie Museum, Pittsburgh, Pennsylvania; *F. Muir*, *Karl Jordan*, *F. G. Rambousek*, *F. Silvestri*.

Entomological Institute for International Service. Discussion leaders: *Walther Horn*, Berlin-Dahlem, Germany, *J. D. Hood*, University of Rochester, Rochester, New York.

(This forum will be concluded on Saturday morning.)

Morphology, Physiology. Embryology, and Genetics

(Room 177, Baker Laboratory)

Chairman: I. P. Kryger, Gentofte, Denmark.

Secretary: Professor O. A. Johannsen, Cornell University, Ithaca, New York.

Der Einfluss der Temperatur auf Eizahl und Eiablage der Lepidopteren, *H. A. Eidmann*, Institut für angewandte Zoologie, Universität, München, Germany.

Insect Polyembryony, *R. W. Leiby,* Department of Agriculture, Raleigh, North Carolina.

The postembryonic development of *Phaenoserphus viator*, a Proctotrypid parasite of the larva of *Pterostichus niger, L. E. S. Eastham,* University, Cambridge, England.

Periodic reversal of heart action in the silk worm moth and pupa, *J. H. Gerould,* Dartmouth College, Hanover, New Hampshire.

Metabolism in insects, *J. H. Bodine,* University of Pennsylvania, Philadelphia, Pennsylvania.

Ecology

(Room 207, Baker Laboratory)

Chairman: Professor Royal N. Chapman, University Farm, St. Paul, Minnesota.

Secretary: Professor James G. Needham, Cornell University, Ithaca, New York.

The insect fauna of thermal springs, *Charles T. Brues,* Bussey Institution, Forest Hills, Massachusetts.

Communication between members of a termite colony, *Alfred Emerson,* University of Pittsburgh, Pittsburgh, Pennsylvania,

Morphological and ecological studies on Chrysopidae, *Milada Cebeova,* Praha, Czechoslovakia [read by *J. Šámal*].

Medical and Veterinary Entomology

(Room 7, Baker Laboratory)

Chairman: Professor E. Martini, Institut für Schiffs- und Tropenkrankheiten, Hamburg, Germany.

Vice-Chairman: Professor W. B. Herms, University of California, Berkeley, California.

Secretary: Professor Robert Matheson, Cornell University, Ithaca, New York.

Mosquitoes in China and their potential relationship to human diseases, *E. C. Faust,* Peking Union Medical College, Peking, China.

The cattle grub (Hypoderma) problem from an international point of view, *F. C. Bishop,* Bureau of Entomology, Washington, D. C.

On the development of malaria parasites in the mosquito host, *W. V. King,* Mosquito Investigations, Bureau of Entomology, Mound, Louisiana.

The present status of our knowledge of the Nyssorhynchus group of tropical American anophelines, *F. M. Root,* School of Hygiene and Public Health, The Johns Hopkins University, Baltimore, Maryland.

Animal coloration and its relation to parasitic attack, *Seymour Hadwen,* University of Saskatchewan, Saskatoon, Saskatchewan, Dominion of Canada.

Apiculture

Meets with Section on Morphology, Physiology, Embryology and Genetics, Room 177, Baker Laboratory.

4:30 p. m. Demonstration of artificial insemination of queenbees, *Lloyd R. Watson,* Alfred, New York, in Amphitheatre, Stimson Hall.

6:30 p. m. Picnic supper for Apiculture Section (see page 29).

Forest Entomology

(Rockefeller Hall, Room B)

Chairman: Dr. Ivar Trägårdh, Statens Skogsförsöksanstalt, Experimentalfältet, Sweden.

Vice-Chairman: Dr. A. D, Hopkins, Branch Laboratory, Bureau of Entomology, Mineral Wells, West Virginia.

Secretary: Professor Glenn W. Herrick, Cornell University, Ithaca, New York.

Die forstliche Bedeutung der Ameisen, *H. A· Eidmann,* Forstliche Versuchsanstalt, München, Germany.

The organization and activities of the Division of Forest Insects, *F. C. Craighead*, Bureau of Entomology, Washington, D. C.

The biology and injury of *Monochamus galloprovincialis* in the fir forests of the Volga, *M. Rimsky-Korsakov,* University, Leningrad, U. S. S. R.

Silvilcultural practices in the control of forest insects, *E. N. Munns,* Forest Service, Washington, D. C.

Barkbeetle epidemics in relation to windfalls, *J. M. Miller,* Forest Insects Laboratory, Bureau of Entomology, Palo Alto, California.

The larch sawfly and forestry, *S. A. Graham,* University of Michigan, Ann Arbor, Michigan.

Economic Entomology

Cereal and Truck Crop Insects

(Room 107, Baker Laboratory)

Chairman: Professor W. J, Schoene, Virginia Polytechnic Institute, Blacksburg, Virginia.

Vice-Chairman: Dr. S. Marcovitch, University of Tennessee, Knoxville, Tennessee.

Secretary: Professor C. R. Crosby, Cornell University, Ithaca, New York.

Pea aphid investigations, *J. E. Dudley Jr.*, Field Laboratory, Bureau of Entomology, Madison, Wisconsin.

De l'emploi du cyanure de calcium comme insecticide en France, *Robert Regnier*, Directeur de le Station entomologique et du Muséum de Rouen, France.

The use of hydrocyanic acid gas in the control cf greenhouse insects, *C. A. Weigel,* Bureau of Entomology, Washington, D. C.

The control of flour mill and stored grain insects, *George A. Dean*, Kansas State Agricultural College, Manhattan, Kansas.

Kitchen garden and truck pests in U. S. S. R., *N. N. Bogdanov-Katjkov,* Institute of Applied Zoology and Phytopathology, Leningrad, U. S. S. R.

Silk industry in Nippon (Japan), *Kanji Watanabe*, Imperial Experiment Station of Sericulture, Tokyo, Nippon.

Insecticides and Appliances

(Rockefeller Hall, Room A)

Chairman: Professor G. M. Bentley, University of Tennessee, Knoxville, Tennessee.

Vice Chairman: Professor H. J. Quayle, Citrus Experiment Station, Riverside. California.

Secretary: Professor Hugh Glasgow, New York Agricultural Experiment Station, Geneva, New York.

Pear Psylla control, *W. A. Ross*, Dominion Entomological Laboratory, Vineland Station, Ontario, Canada.

The characteristics and uses of petroleum oil sprays, *E. R. de Ong*, Berkeley, California.

New stomach poisons for insects, *R. C. Roark*, Bureau of Chemistry and Soils, Washington, D. C.

Cold stream spraying machines, *R. W. Leiby*, State Department of Agriculture, Raleigh, North Carolina.

Some new insecticide-fungicide combinations, *A. Kelsall*, Dominion Entomological Laboratory, Annapolis Royal, N. S., Canada.

3:00-5:00 p. m. Motion pictures, University Theater, Willard Straight Hall.

4:00 p. m. Hea, Willard Straight Hall.

4:00 p. m. and 5:00 p. m. Excursion, University Fish Hatchery (see page 10).

6:00 p. m. No formal meetings are scheduled for this evening, to give opportunity for various groups who may so desire to arrange for dinners, picnics or other informal group gatherings. Sections or individuals desiring such group gatherings should see that information to that effect reaches the Chairman of the Committee on Program so that proper announcements may be made as widely as possible.

6:30 p. m. Picnic supper. Section of Apiculture.

7:30 p. m. Singing on steps of Goldwin Smith Hall.

8:00 p. m. Motion pictures. University Theater, Willard Straight Hall.

8:30 p. m. Excursion, Lick Brook (see page 10).

FRIDAY, AUGUST 17

8:30 a. m. Excursion, Ringwood Wild Life Preserve (see page 11).

9:00 a. m. Meetings of Sections.

Systematic Entomology and Zoogeography

(Main Lecture Hall, Baker Laboratory)

Chairman: Dr. Charles T. Brues, Bussey Institution, Forest Hills, Massachusetts.

Secretary: Professor J. Chester Bradley, Cornell University, Ithaca, New York.

On the classification of beetles according to larval characters, *A. G. Bøving*, Bureau of Entomology, Washington, D. C.

The significance of odonate larvae for general entomology, *Philip P. Calvert*, University of Pennsylvania, Philadelphia, Pennsylvania.

Evolution of the Odonata, *R. J. Tillyard*, Dominion Entomologist, Canberra, T. C. T., Australia.

A palearctic Satyrid: species in the making, *A. Avinoff*, Carnegie Museum, Pittsburgh, Pennsylvania.

Morphology, Physiology. Embryology and Genetics

(Room 177, Baker Laboratory)

Chairman: Professor Herbert Osborn, Ohio State University, Columbus, Ohio.

Vice-Chairman: K. L. Henriksen, Universitetets Zoologiske Museum, København, Denmark.

Secretary: Professor O. A. Johannsen, Cornell University, Ithaca, New York.

The problem of the origin of geographical variation in the Coccinellidae, *Th. Dobzhansky*, University Laboratory for Genetics, Leningrad, U. S. S. R.

A new method for making microscopic slides of Aphids, *Walter Roepke*, Landbouwhoogeschool, Wageningen, Netherlands.

Bau und Funktion des Graber'schen Organs der Tabanidenlarven, *K. W. Baunacke*, Staatl. Landw. Versuchsanstalt, Dresden, Germany.

On the morphology of the female genital organs of the insects belonging to the panorpoid complex, *Alfons Dampf*, Oficina Federal de Defensa Agricola, San Jacinto, D. F., Mexico.

Sex-determination in Lecanium, *Mathias Thomsen*, Kgl. Veterinär- og Landbohojskole, København, Denmark.

Genetics of the Tortricid moth *Acalla comariana*, *J. F. C. Fryer*, British Ministry of Agriculture and Forestry, Harpenden, Herts., England.

Apiculture

(Room 377, Baker Laboratory)

Chairman: Professor Ralph L. Parker, Kansas State College of Agriculture, Manhattan, Kansas.

Secretary: Professor E. F. Phillips, Cornell University, Ithaca, New York.

Studies on the etiology of European foulbrood, *A. G. Lochhead*, Central Experimental Farms, Ottawa, Ontario, Canada

A septicemic condition of adult honeybees, *Carlton E. Burnside*, Bureau of Entomology, Washington, D. C.

The minimum number of spores of *Bacillus larvae* necessary to infect a colony of honeybees, *Arnold P. Sturtevant*, Intermountain Branch Bee Culture Laboratory, Bureau of Entomology, Laramie, Wyoming.

The employment of Caucasian bees in the fertilization of red clover, *A. Skorikov*, State Institute for Experimental Agronomy, Leningrad, U. S. S. R. [read by *W. W. Alpatov*].

The work of the Moscow apicultural experiment station, *A. F. Gubin*, Odinzowo, Moscow, U. S. S. R. [read by *W. W. Alpatov*].

Discussion of proposal made by *Dr. Louis Bahr*, Bakteriologisk Laboratorium, Ratin, København, Danmark, regarding international cooperation in apiculture, with reading of a letter from him on this subject.

Discussion of proposal to affiliate the Apis Club (International) with the International Congress of Entomology.

4:30 p. m. Demonstration of the artificial insemination of queenbees, *Lloyd R. Watson*, Alfred, New York, in Amphitheatre, Stimson Hall.

Forest Entomology

(Rockefeller Hall, Room B)

Chairman: Dr. Charles Hose, British Empire Forestry Association, Redleaf, Purley, Surrey, England.
Vice-Chairman: Dr. E. P. Felt, Bartlett Tree Laboratories, Stamford, Connecticut.
Secretary: Professor Glenn W. Herrick, Cornell University, Ithaca, New York.

Some methods of analysing the fauna of a dying tree, *Ivar Trägårdh*, Statens Skogforsöksanstalt, Experimentalfältet, Sweden.

The present status of the leopard moth (*Zeuzera pyrina*) in the United States, *W. E. Britton*, State Agricultural Experiment Station, New Haven, Connecticut.

Acalla hastiana, the destroyer of willow trees in Czechoslovakia, *Jaromir Šámal*, University, Praha, Czechoslovakia.

Some factors influencing outbreaks of and control of shade-tree insects, *William Middleton*, Bureau of Entomology, Washington, D. C.

An inquiry concerning the natural history of the white pine weevil (*Pissodes strobi*), *T. C. Barnes*, Harvard University, Cambridge, Massachusetts.

Preliminary observations on the Pine Tip moth (Rhyacionia frustrana Comst.) on Southern Pine, *P. C. Wakeley*, Southern Forest Experiment Station, New Orleans, Louisiana.

Economic Entomology

CEREAL AND TRUCK CROP INSECTS

(Room 107, Baker Laboratory)

Chairman: C. F. Howard, Bureau of Entomology, Washington, D. C.
Secretary, Professor C. R. Crosby, Cornell University, Ithaca, New York.

Locusts in Russia for the last ten years, *I. N. Filipjev*, State Institute of Experimental Agronomy, Bureau of Applied Entomology, Leningrad, U.S.S.R.

Die schädlichen Insekten in Bulgarien und die angewandte Entomologie, *P. Tschorbadjieff*, Station agronomique de l'Etat à Sofia, Bulgaria.

An ecological basis for forecasting outbreaks of a serious insect pest, *Eutettix tenellus* Baker, *Walter Carter*, Sugar Beet Insects Field Laboratory, Bureau of Entomology, Twin Falls, Idaho.

Some effects of temperature and moisture upon the activities of grasshoppers and their relation to grasshopper abundance and control, *J. R. Parker*, College of Agriculture, Bozeman, Montana.

Present position of controlling insects injurious to agriculture in U.S.S.R., *Paul I. Adrianov*, Department of Agriculture, Moscow, U.S.S.R.

The destruction of injurious insects before the sowing season of sugarbeet *Francis Rambousek*, Societas Entomologica Czechoslovakiae, Praha, Czechoslovakia.

The present status of economic entomology in Spain, *Demetrio D. de Torres*, Instituto nacional de investigaciones agronómicas, Madrid, Spain.

Field insects of European and Asiatic Russia, with special reference to insects introduced to America, *D. N. Borodin*, New York City.

COTTON INSECTS

(Rockefeller Hall, Room A)

Chairman: John Gray, University of Florida, Gainesville, Florida.
Secretary: Dr. J. W. Folsom, Cotton Insect Laboratory, Bureau of Entomology, Tallulah, Louisiana.

The present Status of the pink bollworm in the United States and Mexico, *C. L. Marlatt*, Chief, Bureau of Entomology, Washington, D. C.

Biological notes on the pink bollworm in Texas, *F. A. Fenton*, Cotton Insect Laboratory, Bureau of Entomology, El Paso, Texas.

The pink bollworm situation in Australia, *F. G. Holdaway*, Adelaide, South Australia.

The pink bollworm in Haiti, *G. N. Wolcott*, Estación Experimental Agricola, Lima, Peru.

Cotton insect control problems in the United States, *B. R. Coad*, Cotton Insect Laboratory, Bureau of Entomology, Tallulah, Louisiana.

The development of a control program for the Mexican cotton boll weevil and some of its results, *W. E. Hinds*, Louisiana State University, Baton Rouge, Louisiana.

Mississippi methods of enforcing quarantines against cotton pests, *R. W. Harned*, A. and M. College, Agricultural College, Mississippi.

The cotton flea hopper, *W. V. King*, Cotton Insect Laboratory, Bureau of Entomology, Mound, Louisiana.

The most important cotton insects in Turkestan and Caucasus, *V. V. Nikolsky*, Moscow, U.S.S.R.

The status of the cotton leaf worm (*Alabama argillacea* Hbn.) in the West Indies, *H. A. Ballou*, Commissioner of Agriculture for the British West Indies, Trinidad, B. W. I.

The pink bollworm in Sudan, *H. H. King*, Sudan.

Cotton seed disinfection as a control for the pink bollworm, *R. E. Mc Donald*, Austin, Texas.

2:00 p. m. **General Session**

(Bailey Hall)

Chairman: Dr. L. O. Howard, Bureau of Entomology, Washington, D. C., President of the Fourth International Congress of Entomology.
Vice-Chairman: Dr. Martin Schwartz, Reichsministerium für Ernährung und Landwirtschaft, Berlin-Dahlem, Germany.
Secretary: Professor O. A. Johannsen, Cornell University, Ithaca, New York.

The share of the Netherlands in the development of entomology in past centuries, *J. B. Corporaal*, Zoologisch Museum, Amsterdam, Netherlands.

Das Mimicryproblem und seine Schwesterprobleme, *Franz Heikertinger*, Zoologisch-Botanische Gesellschaft, Wien, Austria.

Biological control of noxious weeds, *R. I. Tillyard*, Chief Entomologist, Canberra, F. C. T., Australia.

Insect control of noxious weeds, *A. D. Imms*, Rothamsted Agricultural Experimental Station, Harpenden, Herts., England.

Adaptations which prevent or hinder inbreeding in insects, *E. B. Poulton*, University Museum, Oxford, England.

Report of the Permanent Secretary of the Executive Committee, *Karl Jordan*, Tring, Herts., England.

Closing Remarks of the President of the Fourth Congress, *L. O. Howard*.

3:00-5:00 p. m. Motion pictures, University Theater, Willard Straight Hall.

3:30 p. m. Excursion, Six Mile Creek (see page 11).

3:30 p. m. Excursion, Biological Station (see page 11).

4:00 p. m. Tea, Willard Straight Hall.

7:00 p. m. Banquet for all members of the Congress (see page 11).

SATURDAY, AUGUST 18

8:30 a. m. Excursion, McLean Bog (see page 11).

9:00 a. m. Meeting of Section on **Systematic Entomology and Zoogeography.**

(Main Lecture Room, Baker Laboratory)

Chairman: Dr. Karl Jordan, Zoological Museum, Tring, Herts., England.

Vice-Chairman: Professor A. P. Morse, Wellesley College, Wellesley, Massachusetts.

Secretary: Professor J. Chester Bradley, Cornell University, Ithaca, New York.

FORUM ON PROBLEMS OF TAXONOMY

(concluded from Thursday)

Collections. Discussion leaders: *René G. Jeannel*, Vivarium, Muséum National d'Histoire Naturelle, Paris, France, *E. P. Van Duzee*, California Academy of Sciences, San Francisco, California.

Determinations. Discussion leaders: *J. B. Corporaal*, Zoologisch Museum, Amsterdam, Netherlands; *F. Muir* and *R. Jeannel*.

The role of function in taxonomy, and its relationship to the genitalia in insects, *F. Muir*, Experiment Station of the Hawaiian Sugar Planters' Association, Honolulu, T. H.

Validated Bibliography, *E. P. Duzee*, California Academy of Sciences, San Francisco, California.

2:00 p. m. Excursion for all members of the Congress, Enfield-Watkins (see page 11).

2:00 p. m. Excursion for collectors to Michigan Hollow.

SUNDAY, AUGUST 19

8:30 a. m. Excursion, Connecticut Hill (see page 11).
8:39 a. m. Excursion, Niagara Falls (see page 11).
Excursion to chief entomological centers (see page 11).

MONDAY, AUGUST 20

10:00 a. m. Excursion for Apiculture Section (see page 12).
Adirondack excursion for Section of Forest Entomology (see page 12).

TUESDAY, AUGUST 21

Excursion for Apiculture Section (see page 12).

It was a large gathering that listened on Monday morning in the capacious Bailey Hall to the addresses delivered at this first General Meeting. The President, in opening the Congress, said:

"The Entomologists of Canada and the Entomologists of the United States welcome the delegates from other countries to North America. The especial welcome to Ithaca will be given by Dean Hammond of the College of Arts and Sciences and by Dean Mann of the College of Agriculture of Cornell University".

He then called upon Dean Hammond, who extended to the Congress the cordial welcome of the University and Faculty and, after having referred in eloquent words to International meetings at Cornell in other spheres of human thought, where the object of the discussions was the formulating of laws and creeds for human activities, said:

"Your methods, as I understand them, are wholly different. Your discussions are not followed by official decisions that fix a body or code of scientific orthodoxy. On the contrary, your problem is the free and unhampered exchange of theories and opinions and the promotion of the everlasting progress of inquiry. And so you have substituted the logic of induction for the logic of deduction, the logic of discovery for the logic of defence. You will not expect to capture and confine the whole of truth, but through discussion and cooperation you will assist in its pursuit.

"We trust that you will be very comfortable and happy here, that you will carry back to your homes and your laboratories pleasant memories of these days of association with your colleagues in scientific labor, and now in extending to you the hospitality of Cornell University, we wish you god-speed! in all the deliberations of the present Congress."

A. R. Mann, speaking as Dean of the New York State College of Agriculture and Agricultural Experiment Station, said that American scientists, by reason of physical remoteness, had not been able to participate in such gatherings in proportion to their interest in them, and continued:

"In any field of learning, and more particularly in the physical and the biological sciences, the experimental sciences, contact among the workers in similar and cognate fields is the surest guarantee of reliable progress and the greatest incentive to superior achievement; and it is also

conducive to that proper humility of spirit which characterizes the honest seeker after truth. Correspondence and the interchange of publications between individuals — never sufficiently well done — must always be the main dependence, but the association is vastly enriched when personal acquaintance has entered. This, perhaps, is the most valuable product of such international gatherings as this.

"The first quarter of the present century has witnessed the establishment of many financial foundations and governmental grants to provide stipends for young scientific workers to enable them to spend a period of study under a master in a country other than their own. The older scientist, who has more to give and who may profit as much by opportunity to discuss his problems with his peers in other lands, is left largely to his own resources or to the occasional special grants which make it possible for him to represent the institutions of his country in international congresses, where national pride appropriately cooperates. It is in such gatherings that the young scientist looks into the face and hears the voice of the man who has marked the path he is endeavoring to follow; and he gains renewed inspiration, and both the older and the younger are benefitted.

"It is peculiarly appropriate that Agriculture, which is a meeting ground of all the sciences, and the problems and fuller understanding of which are common to all the nations, should be made the occasion for frequent and varied assemblage of the leaders in progress from many lands. In much of the civilized world the solution of the more apparent and the relatively superficial problems of Agriculture has been accomplished, and the time is here when the more fundamental and the more obscure and difficult problems have become the main lines of attack, calling for scientific preparation, application, and collaboration of the highest order. Here, if anywhere, progress will be accelerated by an increasingly close and intimate fellowship among men of science and the integration of minds engaged in related fields of inquiry.

"Cornell University and the New York State College of Agriculture and the State Experiment Station in connection therewith, are sensible of the high privilege which has been accorded them in the selection of this place, made notable by the name Comstock among others, for the Fourth International Congress of Entomology. Of the great importance of the fields of knowledge and research which your members represent we have been conscious from the days of our foundation, and since the opening of the University the teaching and research in Entomology have always had a respected place in our organization. Honored by the presence this week of so great a host of our fellow workers from our sister states of this country, and doubly honored by the great number of distinguished leaders in entomological science from other nations, whose presence makes this Congress particularly notable, we place every facility of this institution at your command. On behalf of my colleagues I cordially greet you and bid you hearty welcome."

Both addresses were received with great acclamation.

The President's address:

"Conservatism of thought is justified up to a certain limit. Beyond that limit it is harmful. And it is just the same in everything. Con-

servatism in medicine has delayed the adoption of many useful ideas, but at the same time it has prevented the general adoption of many foolish ideas. Conservatism in education is perhaps the greatest stumbling-block to progress. Science has had hard work in its efforts to establish itself in educational curricula. Granting that it is now so established, conservatism still plays a most important part in the determination of the relative values of the scientific subjects taught. And in each science, conservatism — custom — still insists that certain aspects shall be stressed and certain others slighted.

"Thus it is in Zoology. In the teaching of this subject since it began to be taught in the colleges and universities Entomology, by far the most important part of this science, has been slighted. In terming Entomology the most important part of Zoology, I do not wish to underestimate the very great value of those zoological studies that relate to how we as animals ourselves came to be; but to the dominant place that the class Insecta holds in the whole animal kingdom.

"I see the time coming, however, — perhaps it is almost here — when the full importance of Entomology will be realized and when those educational institutions which long ago uncloistered themselves from the dominance of the dead languages and higher mathematics will still further broaden their teaching to rank Entomology as a study of prime importance. Many things encourage me in this conclusion A striking phrase has recently come to my attention. It was written by a professor of Zoology in one of the most important universities in the United States — a man of broad training, a man of the present dominant school in zoological instruction. It reads as follows:

> 'In time this may become the age of man, the most highly developed mentally of the vertebrates, but at present he is only beginning to dispute the ascendancy of his rivals, the highly specialized insects crowning the Arthropod series.' (W. C. Allee, The Evolution of the Invertebrates, Chicago, 1926.)

"In these words Dr. Allee has very cleverly put a rapidly growing idea and one which for all these years has been unappreciated and never quite so well formulated. It is a startling thought to egotistical humanity that this is not the age of man; it is the age of insects; that man is a newcomer; that he is as yet an experiment, and that the same may be said of his immediate and in fact of his very remote ancestors — of the whole vertebrate series.

"And why, with all this coming to be more generally realized, even with the teachers (Dr. Allee is Associate Professor of Zoology in the University of Chicago), is there not a teaching reform — why is not Entomology given a vastly greater importance in the leading educational institutions? This question has been asked insistently in Germany recently by Horn, Reh and others, and in fact it has been asked by Walther Horn ever since 1912. One answer may be put in the form of a question: Where are the teachers? Teachers must be taught before they can become teachers. And those teachers that come from the great zoological laboratories can teach little but what they have been taught, and they have not been taught Entomology.

"Even those who admit the very great importance of the subject, if they have looked into the matter at all, must be amazed by the enormous field of entomology — it is a whole world of its own. After a long life spent largely in its study, I find myself, for example, vastly more ignorant than I thought I was forty or even fifty years ago. Perhaps a more or less dim realization of the tremendous scope of Entomology has deterred some competent workers.

"I can imagine the predicament in which my English friend, Dr. George H. Carpenter, found himself when he was asked recently by Prof. J. Arthur Thomson to write a book on the biology of insects, to appear in a series of which the other volumes already published had such titles as "The Biology of Birds," "The Biology of Mammals," "The Biology of Spiders." Carpenter did the book, and it is a remarkably good book; but he was apparently limited to five hundred pages and had to state apologetically in his preface that he was obliged to omit many subjects. As a matter of fact the volume contains fourteen chapters. A book of equal size (500 pages) could have been written under each of these chapter headings; and even then, I am sure, my conscientious friend would have had the feeling that he had hardly done justice to the subject.

"It will probably occur to you that it is not necessary to tell these things to an International Congress of Entomologists. But I contend on the other hand that it is the duty of the President of such a Congress to appreciate most fully, not only the honor that has been paid to him in his selection for the important office, but also the importanee of the Congress and its deliberations, and to formulate this importance in the best phrases at his command.

"In fact, this has already been done in an authoritative way by Professor Lameere in his admirably sound and broad address as President of the first of these Entomological Congresses at Brussels in 1910. He showed clearly the ample reasons why the International Congresses of Zoology did not satisfy the Entomologists and why they could not satisfy them. Zoologists, strictly so called, he said, are usually strangers to Entomology and their preoccupations are usually entirely different from those of the Entomologists. Of course, he was speaking largely of Europeans, but what he said holds well for the rest of the world. The professors of Zoology and their assistants and students are very rarely indeed Entomologists. He makes the interesting statement that if you put these men on the seashore they are entirely in their element and can discuss at length the animals found there; but take them into your garden, and they will tell you that the insects existing there in very great numbers are almost entirely unknown to them.

"I used to wonder in this country why the teacher of Zoology at an inland institution a thousand miles from the seaboard should insist that his laboratory students should devote themselves for hours upon hours to the study of pickled sea-urchins or something of that kind when they were surrounded by instantly available living material in the shape of Insecta with which many important life problems could be studied. I quite agree with Lameere in his statement that the Entomologists are almost as distinct from the Zoologists as the Zoologists are from the Botanists and

that they have accumulated an amount of science at least equal to these other groups. I further agree with him, and very heartily, in the statement that, whereas no one thinks of disputing the separation of the Biologists into Zoologists and Botanists, there will be great advantages in establishing three categories, giving Entomology an importance at least equal to that of Botany or to the rest of Zoology.

"Having made these statements, I have relieved my mind for the moment on a subject which must be advanced strenuously at every opportunity, if Entomology is to for the moment gain the recognition it deserves.

"The three presidential addresses that have been given before the three International Entomological Congresses have differed widely in character, and yet each one was admirable in its way. Professor Poulton at Oxford, after a delightful introductory talk in which he spoke especially of Oxford, the Hope collection of insects, and of Westwood and Henslow and Huxley, devoted the main part of his address to the subject of specific change in relation to geographic distribution and to the organic environment, basing his discussion largely upon a series of *Papilio dardanus*, a subject of broad biological interest which, although the illustration was drawn from Entomology, applied to principles extending through all of Zoology and of Botany as well.

"Three years ago, at Zürich, Dr. von Schulthess adopted still another plan. Very appropriately, he spoke of the long postponement of the Congress from 1912 to 1925 and of the World War which interrupted the proposed Third Congress at Vienna in 1915 and put off all Congresses for many years. He then spoke of the city of Zürich and of the historical development of Entomology in Switzerland from the time of the publication of Sulzer's work in 1761 (fourteen years before Fabricius's first publication). Doubtless this third president, facing the long Zürich program, deemed it best measurably to efface his personality by shortening his remarks. It was a matter of regret for those of us who were present that he did not speak at greater length and give us some of the big ideas he has gained in a lifetime of work. His known standing and his impressive and delightful personality made us all wish to hear more from him, but perhaps his decision was the wisest, and the present speaker is much inclined to follow his example.

"It is not needed that I should speak of American Entomology. Most of us here are Americans. Those who come from other countries are men of wide reading and know of the sound work done here by an older generation, including Leconte, Horn, Scudder and Packard; and they know of the rather remarkable developments of Economic Entomology in the United States. But we are meeting in a university which was one of the first great institutions of learning to teach Entomology as a distinct subject and to give it a measure of its appropriate rank. In this country at least, Cornell University will always be remembered by Entomologists for this fact. And the man who, from the very start in 1872, conducted this invaluable teaching work, J. H. Comstock, lives here. America is so young that few shrines have come into popular recognition. There is one at Mount Vernon, the home of Washington; and there is the memorial in Washington to the great emancipator, Abraham Lincoln.

The study of Entomology seems a very small thing when we compare it to the causes represented by these two of our national heroes, but who shall say that in the future, when the vital importance of insects as affecting the well-being of humanity shall have become fully realized, this spot shall not become in a way a shrine where Entomologists will gather in token of their respect to the first great teacher of entomology in America!

"Very possibly you expect that the present speaker will touch upon the subject of Economic Entomology, a branch of our science with which he has been occupied for many years. The great support that has been given to entomological work with the practical end in view, perhaps notably in the United States, but with rapidly increasing strength in other countries, has not only encouraged the development of many strong workers who have brought about highly valuable results, but it has shown these workers in a very forceful way the basic value of the labors of those ardent Entomologists who have been carried away by the fascinating scientific interest of other aspects ot the science. It is in this way that more and more support is being given to work in Entomology as a whole. It has had its effect upon college laboratories, upon museums and upon Entomologists everywhere. The science through all its innumerable ramifications is acquiring a solidarity which means very much for the future — for the broadest recognition of its importance.

"And so the members of Section 5 (Applied Entomology) will continue to look upon the eminent members of Sections 1, 2, 3 and 4 (Morphology, Anatomy and Physiology; Systematics and Geographical Distribution; Nomenclature and Bibliography; Biology and Evolution) with a deep respect, perhaps tinged with awe. The members of these sections, dealing as they do with "pure" science, will, I trust, look to the Section 5 men as useful members of the Congress who perhaps more than the others are helping to refom the old ideas of Entomology and are bringing public appreciation and public funds to its support.

"To those of you who come from the older countries for the first time we bid especial welcome; and we trust that yon will return with a good opinion of us. We have been accused of self-consciousness; but we are young, and all young people are self-conscious. We have been accused of pride of achievement; but all young people who have a well founded pride are very frank in expressing it. Our faults, then, are the faults of youth; and our accomplishments are those of ambitious, energetic youth, tempered and guided by the learning, experience and culture of the older countries".

At the end of the meeting the Permanent Secretary of the Executive Committee read extracts from telegrams and letters addressed to the Congress:

"The Austrian Minister wishes full success to the Congress, in the proceedings of which his government is highly interested. — The Chargé d'Affaires of Germany expresses his best wishes and refers to the importance of the Congress as a means of furthering international understanding and friendship. — The Minister of Greece extends to the Congress his best greetings and good wishes. — The Hungarian Chargé d'Affaires

sends all good wishes and assures the Congress that its meetings will be watched with great interest in Hungary. — The Italian Ambassador sends cordial greetings to the members of the Congress and is happy in knowing that his country is represented at the meeting. — The Ambassador of Nippon highly appreciates the work done by Entomology for the welfare of humanity and wishes every success. — The Chargé d'Affaires of Norway sends greetings and good wishes. — The Roumanian Minister sends heartiest greetings and good wishes. — The Ambassador of Spain congratulates the President on the occasion of the opening ceremony and is happy that his country is so well represented at the Congress. — Dr. A. von Schulthess and H. Kutter, the President and General Secretary of the Third Congress, extend hearty greetings to the Fourth Congress. — Professors Pospelov of Saratov, Sjöstedt of Stockholm and Zacher of Berlin wish the Congress every success. — In a letter to the President, P. Semenov-Tjan-Shansky, honorary member of the International Congresses of Entomology, conveys to the Fourth Congress the warmest greetings and best wishes and expresses the fervent hope that the meeting will greatly contribute towards strengthening the bonds between America and its western neighbor, the Russian Far East".

The Permanent Secretary then read a letter from J. Jablonowski in which the announcement was made that Dr. L. O. Howard had been elected an Honorary Member of *Királyi Magyar Természettudományi Társulat* and of *Magyar Rovartani Társaság*, and said: "We all know that our President has been honoured often and from many sides for the great work he has accomplished; but the warmth of Jablonowski's words and the happy occasion on which the news of these new honours is conveyed to Dr. Howard are particularly touching. We feel very proud to have Dr. Howard as President of this Congress, and I express to him our most hearty congratulations!"

In the afternoon session of the Section on Nomenclature and Bibliography the Permanent Secretary moved that, for the duration of the Congress, a Committee be appointed to consider the nomenclatural proposals which were before the Congress and to report to a later meeting of the Section. The following members were elected: J. M. Aldrich, C. Bolivar, J. B. Corporaal, J. Chester Bradley, J. E. Sainte-Claire Deville, F. Heikertinger, M. Rimsky-Korsakov, Baron K. von Rosen, W. H. T. Tams and K. Jordan (ex officio). The Permanent Secretary added that, according to precedent, any Congress member could attend the meetings of this Committee and take part in the deliberations, but would not have a vote. The results of the labours of the Committee are embodied in the Report of the Permanent Secretary (cf. p. 75).

At the final session of the Section on Forest Entomology a resolution was passed recommending to the Executive Committee the organization of separate sessions on Forest Insects at the Fifth International Congress of Entomology. — *A priori* there is every reason to accede to the wishes of the Forest Entomologists. The organization of a Congress, however, depends to some extent on the number of papers announced and the accommodation available for Sections.

Shujiro Inomata expressed the wish that Entomologists should use for his country the original and correct name Nippon instead of Japan, which was a corruption of Nippon.

At a session of the Section on Nomenclature A. L. Melander presented a motion that the Congress be urged to emphasize the importance of the foundation of courts for Nomenclature. The motion was seconded by J. M. Aldrich and unanimously carried. — The motion reached the Permanent Secretary too late for incorporation in his Report. The former International Congresses of Entomology have created two courts of Nomenclature: (1) an International Committee on Entomological Nomenclature, assisted by (2) National Committees in countries where such Committees are feasible.

August 16 was an important day for one of the members of the Congress and through him for the Congress itself. Dr. W. J. Holland celebrated on that day in full vigour of mind and body the 80th anniversary of his birth. The Congress congratulated him heartily and affectionately and, in recognition of his great and varied services to Entomology and other branches of learning, elected him an Honorary Member of the International Congresses of Entomology. The Fourth Congress was under special obligation to him, as it was through his influence that the travelling fund for European members was obtained. May fate be kind to Entomology and grant Dr. Holland many further years of good health and activity.

At the last General Meeting, on Friday afternoon, the Permanent Secretary presented his Report, which reads as follows:

Report of the Permanent Secretary of the Executive Committee

Mr. President, Ladies and Gentlemen,

I have the honour to place before you a short Report dealing with various Resolutions and Recommendations on which the present General Business Meeting is asked to come to a final decision.

I. Honorary Members

The Executive Committee in conjunction with the Organising Committee have very great pleasure in proposing to the Congress

(1) that, in addition to Dr. W. J. Holland, who was elected on August 16, Professor S. A. Forbes be elected Honorary Member of the International Congresses ef Entomology in recognition of his high services to our science, and

(2) that a message of sympathy, respect and affection be sent to our Honorary Member Professor J. H. Comstock and to Dr. E. A. Schwarz.

On the motion of the President the proposals are adopted with acclamation.

II. Executive Committee

The Executive Committee is the permanent link between the International Congresses of Entomology, ensuring continuity, undertaking the

work necessary in the intervals between the Congresses, and assisting the Organisation Committee of each Congress. The members of the Executive Committee are

H. Eltringham, Oxford
R. Jeannel, Paris
W. Horn, Berlin-Dahlem
Y. Sjöstedt, Stockholm,
K. Jordan, Tring, and
the President elect of the Congress (who belongs to the Executive Committee ex officio).

After consultation with the President of this Congress the Committee members here present propose

(3) that Professor O. A. Johannsen be elected a member of the Executive Committee (to replace the late Dr. H. Skinner). — Carried unanimously.

The members of the Executive Committee have so far been elected for life. But the Executive Committee considers it advisable that there should be a bye-law governing the term of office of the members, and therefore places before the Congress a recommendation to the effect

(4) that the members of the Executive Committee be elected for a period of three Congresses and that at every Congress one-third of the members retire according to seniority, but that such members be eligible for re-election, provided that they have attended at least one Congress within the term of their office. — Carried unanimously.

III. Nomenclature

The Section on Nomenclature and Bibliography elected on Monday for the duration of this Congress a Committee of nine members (cf. p. 74), to whom the Section entrusted the task of discussing certain questions of Nomenclature and the status of the International Committee on Entomological Nomenclature. The results of the deliberations of this Committee were placed before the Section on Nomenclature which met this morning together with the Section on Systematics. The combined Sections recommend

(5) that the members of the International Committee on Entomological Nomenclature be elected for a period of three Congresses and that at every Congress one third of the members retire according to seniority, but that such members be eligible for re-election, provided that they have attended at least one Congress within the term of their office; — carried unanimously;

(6) that the Congress endow the International Committee on Entomological Nomenclature with judiciary power to decide purely Entomological cases in Nomenclature (with the International Commission on Zoological Nomenclature as a court of appeal); — carried unanimously;

(7) that Art. 4 of the Report presented by the British National Committee on Entomological Nomenclature be amended by the substitution of the last nine words by "such included genus, whatever its valid name, should then be regarded the type-genus"; — carried unanimously;

(8) that Art. 5 of said Report be referred back to the British National Committee for study, with an approval of the general principle involved; — carried unanimously;

(9) that Art. 14 of said Report (and "at" Art. 14) be referred back to the British National Committee for further consideration and report; — carried unanimously;

(10) that the balance of said Report be referred, without prejudice, to the Commission on Zoological Nomenclature for consideration, after the said Report has been approved by the International Committee on Entomological Nomenclature; — carried unanimously.

The Sections above mentioned further recommend to the Congress the acceptance and adoption of the following additional resolutions:

(11) The type-genus of a family or subfamily shall be the contained genus of which the stem of the name was first employed in combination with a termination in Latin plural form to designate a group higher than genus, and that, if any Latin termination was originally used other than provided for in Article 4 of the Code on Zoological Nomenclature, said termination shall be changed to bring it into conformation with that Article 4; — carried unanimously;

(12) the name of a family or subfamily shall date from the time it was first proposed for a group higher than genus, provided that it was based on a contained generic name; — carried unanimously;

and (13) that the Congress draw the attention of the Commission on Zoological Nomenclature to the existence of three indices in the 12th edition of Linnaeus, Systema Naturae, and that Linnaeus, in these indices, dit not mention the designations of the subdivisions of his genera under *Nomina,* but under *Termini*; — carried unanimously.

IV. Cataloguing

The Section on Systematic Entomology and Zoogeography recommends to the Congress

(14) that a Committee be appointed to study the subject of cataloguing insects, to draft a plan of action and to work out the details for preparing and publishing an Index to the Literature of the Species of Insects; the Committee to consist of Dr. J. Chester Bradley, Monsieur A. Ball and Mr. E. T. Cresson Jr. (the last named to act as secretary), with the power to coopt additional members as the Committee deems advisable; — carried unanimously;

and (15) that the Congress express the desirability that Institutions and owners of private Collections publish a list of the *Types* contained in their collections; — carried unanimously.

V. Entomological Institute for International Service

The same Section further recommends

(16) that a Committee be appointed consisting of Messrs. J. Chester Bradley, W. Horn, K. Jordan, F. Muir and J. Waterston (with W. Horn as secretary) to inquire into the feasibility of some such Entomological Institute for International Service as advocated by Dr. W. Horn in his address read before the Section on Thursday and to take all possible steps towards the realization of the project, the Committee being empowered to elect temporary members at its discretion; — carried unanimously.

VI. Finances

It is necessary to draw the attention ot the Meeting to the Assets and Liabilities of the International Congresses of Entomology. The expenses incurred by the issue of the Proceedings and Transactions of the Congresses have always been larger than the sum of money left over from the membership fees after deduction of the expenses of the Organising Committee. To cover the deficit the Executive Committee has solicited (and received) donations and has appropriated a portion of the life-membership fees. The total remaining capital invested by the Trustees of the funds of the Congresses (Lord Rothschild and Dr. H. Eltringham) amounts to about $ 700.—, and the Permanent Secretary has approximately $ 75.— in hand. In addition, there are available for sale 4 complete sets of the three former Congresses and a number of further copies of the publications of the First and Second Congresses.

It is most desirable that the Congresses should possess a much larger capital, of which the interest could be used for supplementing the publication funds of each Congress. The publications of these Congresses being of a distinctly International nature, some way may perhaps be found to acquire an adequate foundation.

The last proposal in the Report refers to the place and year of the next Congress:

VII. The Fifth International Congress of Entomology

As the French Entomological Society will celebrate its centenary in 1932, the Executive Committee considers it highly desirable that the Fifth International Congress of Entomology should meet on that very opportune occasion. Our French friends invite the Congress to hold its meeting in Paris in 1932. The election of the President may be left in the hands of the Executive Committee and the Société Entomologique de France. — Monsieur E. L. Bouvier having adressed the Meeting on this subject, the President moves that the Fifth International Congress of Entomology meet in Paris in 1932. — Carried with acclamation.

This concludes the Report of the Permanent Secretary of the Executive Committee.

Karl Jordan.

We add summaries of the Report in French and German.

Les motions suivantes sont adoptées par le Congrès à l'unanimité:

(1) M. le Dr. W. J. Holland et M. le professeur S. A. Forbes sont élus Membres Honoraires des Congrès Internationaux d'Entomologie.

(2) Un message de sympathie, de respect et d'affection est adressé à M. le professeur J. H. Comstock et à M. le Dr. E. A. Schwarz.

(3) M. le professeur O. A. Johannsen est élu membre du Comité exécutif.

(4 et 5) Les membres du Comité exécutif et les membres du Comité International de Nomenclature Entomologique sont élus pour une période de trois Congrès, et à chaque Congrès un tiers de ces membres sera renouvelé par rang d'ancienneté; mais ces membres sont rééligibles, à la condition qu'ils aient assisté au moins à un Congrès pendant la durée de leurs fonctions.

(6) Le Congrès donne pleins pouvoirs au Comité International de Nomenclature Entomologique pour prendre des décisions en ce qui concerne la nomenclature entomologique (la Commission Internationale de Nomenclature Zoologique étant une cour d'appel).

(7) L'Article 4 du rapport présenté au Congrès par le Comité Britannique de Nomenclature Entomologique est modifié en remplaçant les neuf derniers mots par: « que ce genre, quelque soit la validité de son nom, soit considéré comme genre-type».

(8) L'Article 5 du dit rapport est renvoyé au Comité Britannique de Nomenclature pour étude complémentaire, avec approbation toutefois de son principe général.

(9) L'Article 14 du dit rapport (et les recommandations correspondantes: «At Art. 14») est renvoyé au Comité Britannique pour examen complémentaire et nouveau rapport.

(10) Le restant du dit rapport est soumis, sans préjudice, à la Commission de Nomenclature Zoologique, après avoir été adopté par le Comité International de Nomenclature Entomologique.

(11) Le genre-type d'une famille ou sous-famille sera le genre contenu dans cette famille ou sous-famille, dont le radical du nom aura été employé pour la première fois avec la terminaison latine au pluriel pour désigner un groupe plus élevé que le genre; mais si la terminaison latine originairement employée était autre que celles prévues à l'Article 4, elle devra être changée, conformément à cet Article 4.

(12 Le nom d'une famille ou sous-famille prendra date de l'époque où il aura été proposé pour la première fois pour un groupe plus élevé que le genre, pourvu qu'il ait été formé d'après un nom de genre inclus dans ce groupe.

(13) Le Congrès attire l'attention de la Commission de Nomenclature Zoologique sur le fait que dans la XIIe édition du Systema Naturae Linné a rédigé trois tables alphabétiques, et que Linné, dans ces tables, ne fait pas mention des désignations des subdivisions des genres comme «Nomina», mais comme «Termini».

(14) Un Comité est désigné pour étudier les principes d'un Catalogue des Insectes, et préparer un plan de travail en vue de rédiger et publier un Index de la littérature concernant toutes les espèces d'Insectes. Ce Comité est constitué par MM. J. Chester Bradley, A. Ball et E. T. Cresson Jr. (ce dernier faisant fonction de secrétaire) et aura pouvoir de s'adjoindre des membres supplémentaires.

(15) Le Congrès exprime le désir que les Instituts et les possesseurs de collections privées publient une liste de leurs types.

(16) Un Comité est constitué (MM. J. Chester Bradley, K. Jordan, F. Muir, J. Waterston et W. Horn, secrétaire) pour faire une enquête sur la possibilité de fonder un Institut International Entomologique selon les propositions faites par W. Horn; le Comité a pouvoir de s'adjoindre des membres temporaires.

(17) Le prochain Congrès International d'Entomologie aura lieu à Paris en 1932.

Der Kongreß erhob die folgenden Anträge einstimmig zum Beschluß:

(1) Die Herren Dr. W. J. Holland und Professor S. A. Forbes wurden zu Ehrenmitgliedern der Internationalen Entomologen-Kongresse gewählt.

(2) Den Herren Professor J. H. Comstock und Dr. E. A. Schwarz drückte der Kongreß brieflich seine Sympathie, Hochachtung und Verehrung aus.

(3) Herr Professor O. A. Johannsen wurde zum Mitgliede des Exekutivkomitees erwählt.

(4 und 5) Die Mitglieder des Exekutivkomitees und des Internationalen Komitees für entomologische Nomenklatur sind für eine Periode von 3 Kongressen gewählt; auf jedem Kongresse scheidet der Amtsdauer entsprechend ein Drittel der Mitglieder aus, doch kann jedes Mitglied wiedergewählt werden, vorausgesetzt, daß das ausscheidende Mitglied während seiner Amtsdauer wenigstens einen Kongreß mitgemacht hat.

(6) Dem Internationalen Komitee für entomologische Nomenklatur wird Vollmacht erteilt, rein entomologische Nomenklaturfragen zu entscheiden (die Internationale Zoologische Nomenklaturkommission als Appellationshof).

(7) In Art. 4 des vom Britischen Nationalkomitee eingereichten „Reports" werden die letzten 9 Worte ersetzt durch: „welche Gattung, was auch ihr gültiger Name sein mag, dann als typische Gattung angesehen werden soll.

(8 und 9) Art. 5 und 14 (sowie „At Art. 14") werden an das Britische Nationalkomitee zu weiterer Beratung zurückverwiesen.

(10) Der Rest des Reports soll, ohne Vorurteil, der Kommission für Zoologische Nomenklatur unterbreitet werden, nachdem er von dem Internationalen Entomologischen Nomenklaturkomitee gutgeheißen ist.

(11) Die typische Gattung einer Familie oder Unterfamilie ist die darin enthaltene Gattung, deren Namenstamm zuerst durch Hinzufügung einer lateinischen Pluralendung zur Bezeichnung einer über der Gattung stehenden Gruppe gebraucht worden ist. Wenn diese lateinische Endung nicht der in Art. 4 der Zoologischen Nomenklaturregeln vorgeschriebenen Form entspricht, ist die Endung Art. 4 gemäß zu ändern.

(12) Der Name einer Familie oder Unterfamilie datiert von dem Zeitpunkt ab, wo er zuerst für eine über der Gattung stehende Gruppe vorgeschlagen wurde, vorausgesetzt, daß er von dem Namen einer in der Familie oder Unterfamilie enthaltenen Gattung abgeleitet wurde.

(13) Der Kongreß lenkt die Aufmerksamkeit der Internationalen Kommission für Zoologische Nomenklatur auf die Tatsachen, daß in der XII. Auflage von Linné, Syst. Nat., 3 Indices vorhanden sind und daß Linné die Bezeichnungen der Unterabteilungen seiner Gattungen nicht unter *Nomina*, sondern unter *Termini* aufführt.

(14) Der Kongreß beauftragt ein aus den Herren J. Chester Bradley, A. Ball und (als Schriftführer) E. T. Cresson Jr. bestehendes Komitee, die Methode des Katalogisierens der Insekten zu studieren, einen Organisationsplan zu entwerfen und Vorschläge für die Zusammenstellung und Veröffentlichung eines Index der Literatur der Insektenspecies zu

machen, und gibt dem Komitee Vollmacht nach eignem Ermessen weitere Mitglieder zu ernennen.

(15) Der Kongreß erklärt es für wünschenswert, daß Institute sowie Besitzer von Privatsammlungen eine Liste der in ihren Sammlungen vorhandenen Typen veröffentlichen.

(16) Der Kongreß beauftragt ein aus den Herren J. Chester Bradley, K. Jordan, F. Muir, J. Waterston und (als Schriftführer) W. Horn bestehendes Komitee, die Frage zu untersuchen, ob sich ein Entomologisches Institut für Internationalen Dienst, wie es von Dr. W. Horn angeregt wurde, ermöglichen läßt und alle nötigen Schritte zur Verwirklichung des Vorschlags zu unternehmen, und gibt dem Komitee Vollmacht, nach eignem Ermessen zeitweilige Mitglieder zu wählen.

(17) Der nächste Internationale Entomologen-Kongress wird 1932 in Paris stattfinden.

Before closing the Congress the President shortly addressed the Meeting as follows:

"The most obvious characteristic of this Congress has been enthusiam. All of us have felt it in an extraordinary degree. It is by far the largest meeting of entomologists ever held and its international character makes it the most important. It has marked to a striking extent the rapidly growing interest in Entomology as a Science and the wide-spread appreciation of its importance. In these respects the Congress has been a monumental milestone.

"But these great broad things must not be allowed to overshadow other matters which, though seemingly lesser in themselves, lead up to greater things: international understanding and cooperation. Of the hundreds of American entomologists (and by American I mean those working both in Canada and the United States) who have attended this Congress, not one will ever miss a chance in the future to join International Congresses. So great has been the success of this one that all of us will go back to our homes not only with greater enthusiasm for Entomology, but with every feature of this international gathering impressed on his mind and with a great respect and personal liking for his colleagues from the other parts of the world. You men and women from the other countries by your journey here have broadened our outlook very greatly. We knew your work, we now know your personalities and we clasp hands with you in warm friendship.

"I am glad that the next Congress is to be held in Paris and that its date will coincide with the one hundredth anniversary of the founding of the great Société Entomologique de France. I predict with conviction that, while it can hardly be more delightful in certain of its aspects than the present Congress, it will bring together hundreds of additional workers and will rank as another and still higher peak in the ascent of entomology from its unconsidered beginnings to the rank that it will achieve in the minds of thinking people. I can assure Professor Bouvier and his French colleagues that every American here today will try hard to greet them in Paris in 1932. Long live Entomology!"

The official dinner on Friday evening at Willard Straight Hall was attended by a large number of members. As a special feature the after-dinner speeches were delivered in a great variety of tongues, the Toast Master (the President) having requested one delegate of each country shortly to address the gathering in the language of the country he represented. It was a most amusing experience and without the disastrous results of the diversity of tongues that prevented the completion of the tower of Babel.

The dinner with the dance after it was the end of the official Congress for the majority of the members. But the Taxonomists, ever hungering after more and more work, had a further meeting provided for them on Saturday morning, at which the writer of these lines was to take the chair. When he leisurely walked up to Baker Laboratory, he expected to be the only occupant of the spacious Lecture Hall; but to his surprise and delight (mixed with regret?), the meeting was a very full one, and the discussions were most interesting and fruitful.

Judging from the various accounts which have come to hand of the excursions after the Congress, the European members had a great time, occasionally tempered by a little shock, such as the one which (literally) took their breath away when Dr. Holland addressed his guests at Pittsburgh in fluent Latin.

Appendix

Dr. Walther Horn: **Entomological Institute for International Service.**

The aim of the Institute would be to give advice to Entomologists of all branches in every way, with the exception of nomenclature and practical service in applied entomology. Cooperation and organization of the entomologists of the world would be the basis of the Institute.

I. The chief requirements of the Institute would be: 1. a library and 2. card indexes. A very small collection of insects would be sufficient for the purpose of reference. Special stress would be laid on correspondence and on personal contact with entomologists. The card indexes would contain: 1. addresses of scientists, amateurs, collectors, museums, institutes, societies and journals; 2. common names and termini technici; 3. historical and biographical data, obituaries, photographs of entomologists; 4. subject indexes or «Sachregister» as in the Zoological Record and Hagen's Bibliotheca Entomologica, with special attention to local lists; 5. a list of specialists who are willing to work out special groups of insects, and a corresponding list of groups of insects for which specialists are required.

II. Explanatory service to stimulate entomologists to take up different groups of insects so as to avoid duplication. Special attention to be drawn to groups of practical interest for applied entomology.

III. Propaganda for provisional check lists, local lists, catalogues of every kind; advice as to the most useful arrangement of such lists and

the cheapest way of publication; special arrangements with a printing office in a country where the printing of such standard lists would be relatively cheap.

IV. Gradually to build up a card index of the whole entomological literature from 1863, with the object of issuing the whole bibliography up to 1925 as one series, continuations to appear every 25 years.

V. The Institute could be charged with propaganda and secretarial service for the International Congresses of Entomology, with making their resolutions better known and with drawing up a preliminary agenda for the meetings, without power of decision.

VI. Building up a large library for international service; supplying cheap photostatical reprints; in special cases lending to scientists books that might otherwise not be accessible.

VII. The best place for the institute would perhaps be Switzerland; Zürich would be very suitable.

[illegible] New York, August 12 to 18, 1928

1. W. J. Brown
2. G. Stewart Walley
3. Sara L. Harris
4. Eva M. Tully
5. John H. Gerould
6. William G. Lebowitz
7. Max Poser
8. A. B. Wells
9. F. L. Gambrell
10. Rodney Cecil
11. Birely J. Landis
12. J. R. Parker
13. Yeshwantras P. Bhosale
14. H. C. Huckett
15. Theo. H. Eaton, Jr.
16. W. J. Holland
17. M. Cameron
18. I. P. Kryger
19. W. H. Brittain
20. A. B. Baird
21. C. H. Popenoe
22. E. G. Smyth
23. N. F. Howard
24. R. E. Mackie
25. William Tyson
26. Fritz Stellwaag
27. H. Eidmann
28. C. L. Marlatt
29. A. Dampf
30. K. Baunacke
31. W. Knechtel
32. J. Samal
33. Rev. J. Assmuth
34. G. C. Crampton
35. E. H. Wheeler
36. E. F. Phillips, Jr.
37. H. W. Parshley
38. Glenn W. Herrick
39. Robert Matheson
40. Julian P. Scott
41. Myron Gordon
42. P. W. Claassen
43. H. M. Tietz
44. W. W. Alpatov
45. D. N. Kaschkaroff
46. M. E. Ryberg
47. D. J. Caffrey
48. L. H. Patch
49. Mrs. J. A. Munro
50. J. A. Munro
51. J. B. Corporaal
52. E. D. Ball
53. M. N. Rimsky-Karsakow
54. Herbert Osborn
55. Mrs. J. R. Parker
56. V. Bayonnet
57. A. d'Orchymont
58. L. d'Orchymont (Miss)
59. W. S. Blatchley
60. E. P. Felt
61. W. M. Wheeler
62. F. Silvestri
63. L. O. Howard
64. Karl Jordan
65. E. L. Bouvier
67. S. A. Forbes
68. A. G. Bōving
69. N. A. Kemner
70. A. B. Martynov
71. G. Enderlein
72. Richard Bledowsky
73. Walter Roepke
74. Elizabeth Skwarra
75. R. Streda
76. Max Dingler
77. P. Tshorbadjiev
78. F. Rambousek
79. V. Nickolsky
80. A. B. Comstock
81. P. Vayssière
82. Mme. Regnier
83. R. Jeannel
84. R. Regnier
85. R. J. Tillyard
86. J. C. F. Fryer
87. A. D. Imms
88. L. E. S. Eastham
89. G. Fox Wilson
90. H. L. Dozier
91. R. S. Filman
92. F. L. Campbell
93. W. Rupdolfs
94. J. S. Boyce
95. Aug. Busck
96. John Glassford
97. P. I. Lathy
98. A. A. Granovsky
99. Mrs. A. A. Granovsky
100. I. L. Ressler
101. F. Z. Hartzell
102. Henry G. Good
103. Antoine Ball
104. E. Martini
105. William A. Riley
106. Marshall Hertig
107. G. Ceballos

108. D. D. de Torres
109. A. B. Gahan
110. James Waterston
111. Augusto Merchán
112. P. R. Rincones
113. J. Montano Novella
114. Carl Heinrich
115. Mrs. C. P. Alexander
116. C. P. Alexander
117. H. H. Richardson
118. Theodore H. Hubbell
119. Alberto Graf
120. Walther Horn
121. J. G. Sanders
122. Theodore Dobzhansky
123. I. N. Filipjev
124. H. A. Scullen
125. B. A. Slocum
126. Philip Luginbill
127. August I. Balzer
128. B. Trouvelot
129. J. Sainte Claire Deville
130. F. Heikertinger
131. Mrs. S. C. McIndoo
132. N. E. McIndoo
133. Mrs. N. E. McIndoo
134. Mrs. E. N. Cory
135. E. N. Cory
136. E. F. Phillips
137. Millard C. Van Duzee
138. C. H. Newman
139. W. P. Flint
140. M. P. Jones
141. D. J. Jackson
142. Norma Ford
143. K. C. Sullivan
144. George P. Engelhardt
145. A. B. Klots
146. P. H. Timberlake
147. J. Speed Rogers
148. Mrs. J. C. Pallister
149. J. C. Pallister
150. Anna Hartzell
151. Albert Hartzell
152. Jas. S. Hine
153. Raymond C. Osburn
154. V. A. Little
155. Auburn E. Brower
156. Paul N. Musgrave
157. Andrew R. Park, Jr.
158. George S. Langford
159. George B. Bisset
160. John Carroll
161. William P. Hayes
162. Mrs. William P. Hayes
163. B. B. Fulton
164. Royal N. Chapman
165. Josephine Burns Glasgow
166. Ivar Trägardh
167. Robert D. Glasgow
168. G. J. Spencer
169. Cornelius Betten
170. Edgar Nelson
171. Charles W. Leng
172. Mrs. J. R. de la Torre Bueno
173. J. R. de la Torre Bueno
174. John D. Sherman, Jr.
175. A. L. Strand
176. S. Marcovitch
177. O. A. Johannsen
178. C. M. Packard
179. W. H. Larrimer
180. Clarence H. Kennedy
181. D. M. DeLong
182. C. W. Stiles
183. Unio Saalas
184. E. Marsden
185. Mrs. R. E. Snodgrass
186. R. E. Snodgrass
187. W. J. Baerg
188. Mrs. E. E. Hose
189. Charles Hose
190. Ralph S. Hosmer
191. Margr. Marsden
192. Mrs. S. B. Fracker
193. Doris M. Fracker
194. J. Chester Bradley
195. Mrs. Virgil N. Argo
196. Hilda Jordan
197. Ada Jordan
198. Walter Carter
199. G. F. Ferris
200. G. Talbot
201. Edwin C. Van Dyke
202. W. B. Herms
203. W. T. M. Forbes
204. Harold Morrison
205. Emily Morrison
206. T. E. Snyder
207. Mabel Colcord
208. Miss Lucy Howard
209. P. W. Mason
210. R. W. Leiby
211. F. C. Fletcher
212. Louise M. Russell
213. J. S. Stanford
214. M. A. Stewart
215. James E. Collins
216. A. Avinoff
217. L. B. Prout
218. J. S. Houser
219. Hugo Kahl

220. J. Harold Matteson
221. T. H. Parks
222. C. R. Neiswander
223. D. N. Borodin
224. Hugh Glasgow
225. W. J. Schoene
226. Percival J. Parrott
227. Robert L. King
228. J. J. Davis
229. T. B. Mitchell
230. Chris E. Olsen
231. F. E. Lutz
232. F. M. Brown
233. L. S. McLaine
234. K. M. King
235. Henry Bird
236. I. A. Parfentjev
237. Grace E. Glance
238. Edwardo Gridelli
239. George Salt
240. W. H. Tams
241. A. P. Sturtevant
242. Ethel L. Coon
243. Jas. I. Hambleton
244. P. P. Babiy
245. Mrs. L. A. H. Peters
246. Mrs. L. H. Weld
247. Mrs. H. L. Knight
248. Mrs. Leonard Haseman
249. J. G. Needham
250. Virgil N. Argo
251. F. W. Edwards
252. Mrs. F. M. Edwards
253. K. Watanabe
254. S. Inomata
255. Vasco M. Tanner
256. John Gray
257. Frank E. Blaisdell, Sr.
258. R. C. Roark
259. G. M. Bentley
260. Iva Hawes
261. Mrs. T. E. Snyder
262. Katheryn Slingerland Buys
263. John L. Buys
264. Hugo Hartnack
265. E. C. Faust
266. E. J. Anderson
267. J. O. Pepper
268. N. D. Riley
269. H. L. Knight
270. T. H. Frison
271. S. H. Williams
272. Alfred Emerson
273. A. M. Nadler
274. L. L. Huber
275. C. O. Eddy
276. J. Douglas Hood
277. W. V. Balduf
278. Joseph Bequaert
279. William Wild
280. S. M. Dohanian
281. F. M. Root
282. B. P. Young
283. D. A. Wilbur
284. E. Melville Du Porte
285. C. Bolivar y Pieltain
286. Mary M. Glance
287. George C. Wheeler
288. K. von Rosen
289. Charles H. Ballou
290. Mrs. Charles H. Ballou
291. L. A. H. Peters
292. Mrs. C. R. Crosby
293. Mrs. Glenn W. Herrick
294. Mrs. C. O. Eddy
295. Mrs. W. W. Yothers
296. Mrs. J. M. Aldrich
297. Mrs. P. R. Needham
299. George C. Embody
300. Donald T. Ries
301. E. R. de Ong
302. Clarence E. Mickel
303. Mrs. C. E. Mickel
304. C. K. Sibley
305. S. W. Frost
306. Lewis H. Weld
307. T. E. Holloway
308. Mrs. R. C. Roark
309. E. A. Back
310. F. Muir
311. Alfred Weed
312. Ed. M. Searls
313. A. D. Bourne
314. A. V. Mitchener
315. D. E. Fink
316. N. S. Fink
317. F. G. Holdaway
318. Don C. Mote
319. George A. Filinger
320. Arthur Gibson
321. W. E. Hinds
322. George I. Reeves
323. Stanley E. Flanders
324. R. G. Schmieder
325. C. R. Cutright
326. Alan Stone
327. A. L. Brody
328. George W. Walton
329. C. H. Curran
330. W. H. R. Werner
331. S. C. Jones
332. Henry N. Goddard

333. A. G. Ruggles
334. A. C. Baker
335. Leif R. Natvig
336. Mrs. Tragardh
337. Mathias Thomsen
338. William S. Marshall
339. Mrs. Philip P. Calvert
340. D. L. Van Dine
341. R. W. Harned
342. Mrs. A. B. Gahan
343. Mrs. W. E. Britton
344. Mrs. R. D. Harwood
345. J. A. B. Nolla
346. R. D. Harwood
347. Mrs. Myron Swenk
348. William Middleton
349. H. J. MacAloney
350. A. R. Shadle
351. J. A. Manter
352. H. C. Efflatoun
353. Sybil F. Graham
354. Lloyd M. Bertholf
355. Mrs. Martha Bertholf
356. S. B. Fracker
357. F. H. Benjamin
358. Mrs. L. G. Gentner
359. A. R. Prince
360. F. W. Poos
361. Wm. A. Hooker
362. J. A. Hyslop
363. W.W.Yothers
364. W. A. Fowler
364A. C. T. Vorhees
365. Ida L. Reveley
365A J. Swezey, Jr.
366. W. J. Willis
366A. O. H. Swezey
367. C. F. Adams
368. Ralph L. Parker
369. Chas. O. Dirks
370. Leonard Haseman
371. Myron H. Swenk
372. Geo. M. List
373. G. E. R. Hervey
374. W. E. Britton
375. A. P. Morse
376. E. H. Hinman
377. G. F. White
378. C. E. Burnside
379. F. M. Jones
380. P. P. Calvert
381. Mrs. E. F. Phillips
382. O. W. Richards
383. Ruth Oertel
384. E. Oertel
385. Nulo A. Vappula
386. Kai C. Henriksen
387. Geo. Rea
388. P. R. Needham
389. W. S. Hough
390. F. N. Spaeth
391. P. T. Barnes
392. Ralph D. Dickey
393. F. S. Blanton
394. A. L. Treadwell
395. Prof. M. W. Blackman
396. Dr. F. C. Craighead
397. Wm. T. Davis
398. Raymond L. Taylor
399. L. G. Gentner
400. A. L. Melander
401. Mrs. A. L. Melander
402. C. W. Johnson
403. H. L. Parten
404. R. R. Parker
405. Clarence O. Bare
406. Seymour Hadwen.
407. O. C. McBride
408. J. M. Aldrich
409. J. L. Horsfall
410. Ann Morgan
411. Miss Cattell
412. Jacques Cattell
413. A. E. Stene
414. J. McK. Cattell
415. W. E. Rumsey
416. William H. Gurney
417. C. S. Thompson
418. Carryl Parker Haskins
419. Mrs. Carryl P. Haskins
420. Curtis Benton
421. G. Maheux
422. E. J. Hambleton
423. George A. Dean
424. G. H. Lamson, Jr.
425. Leroy Childs
426. Harry S. Smith
427. Franklin W. Pettey
428. A. F. Burgess
429. J. S. Wade
430. Wm. J. Gerhard
431. R. M. Geist
432. C. A. Thomas
433. Henry Dietrich
434. Mrs. A. G. Baker
435. A. W. Baker
436. Herbert Ruckes
437. Mrs. Herbert Ruckes
438. H. J. Quayle
439. Vernon R. Haber
440. B. A. Porter
441. P. G. Mundinger

928[2]

OURTH INTERNATIONAL CONGRESS OF ENTOMOLOGY
ITHACA, AUGUST 1928

VOLUME II

TRANSACTIONS

EDITED BY

K. JORDAN AND W. HORN

ISSUED DECEMBER 1929

VIII + 1037 pages, 183 figures, diagrams and maps in text, and 12 plates

Communications to be addressed to Dr. K. Jordan, Zoological Museum, Tring (Herts.), England

PRINTED BY
GOTTFR. PÄTZ, NAUMBURG A/SAALE, WENZELSRING 5.

FOURTH INTERNATIONAL CONGRESS OF ENTOMOLOGY
ITHACA, AUGUST 1928

VOLUME II

TRANSACTIONS

EDITED BY

K. JORDAN AND W. HORN

ISSUED DECEMBER 1929

VIII + 1037 pages, 183 figures, diagrams
and maps in text, and 12 plates

Communications to be addressed to Dr. K. Jordan,
Zoological Museum, Tring (Herts.), England

PRINTED BY
GOTTFR. PÄTZ, NAUMBURG A/SAALE, WENZELSRING 5.

Contents.

Alphabetical Index of Authors.

Some new Insecticide-Fungicide Combinations.

A. Kelsall, Dominion Entomological Laboratory,
Annapolis Royal, N. S., Canada.

This paper is a brief summary of results obtained on apple orchards in the Maritime Provinces of Canada from the experimental use of a group of precipitated lime-sulphur mixtures. The precipitating agents used were 1. zinc sulphate, 2. iron sulphate, and 3. aluminium sulphate, each of which was used in such amount as to be just a little short of causing complete precipitation, namely 4½ lbs., 4 lbs., and 3½ lbs. respectively, per imperial gallon of concentrated lime-sulphur of 1.3 specific gravity. These sprays were used alone and also in conjunction with lead arsenate, calcium arsenate and nicotine sulphate. In the preparation of the sprays, the metallic sulphates were dissolved and diluted with the requisite amount of water, to which was then added the concentrated lime-sulphur, and finally the insecticide. In the various spray mixtures the ingredients were used in the following amounts per 40 imperial gallons: — lime sulphur 1 imperial gallon, lead arsenate 1 lb., calcium arsenate ¾ lb., nicotine sulphate ½ pint. These spray mixtures were compared with plots receiving no treatment and with such standard sprays as lime-sulphur lead arsenate, the main basis of comparison being the relative insecticidal and fungicidal efficiency and safety to fruit and foliage.

Zinc sulphate and Lime-sulphur Mixture.

This mixture was used during two seasons and in four orchards. From an insecticidal standpoint when combined with lead or calcium arsenates, the results were variable and no sufficient data were obtained to appraise its value with certainty, though most evidence pointed to it being inferior to lime-sulphur lead arsenate. As a fungicide, this mixture with calcium arsenate was superior to the mixture alone or the mixture with nicotine, but even the best combination was inferior to the standard spray. The foliage on plots treated with this mixture, with and without the various insecticides, was for the most part poorer than that of the standard plots.

Iron sulphate and Lime-sulphur Mixture.

This mixture was used during three seasons and in five orchards.

Combined with nicotine, the mixture gave results in insect control quite similar to lime-sulphur and nicotine, while combined with either lead arsenate or calcium arsenate results were obtained which were quite satisfactory, though possibly slightly inferior to the standard sprays.

As a fungicide this mixture was greatly influenced by the particular insecticide used, being much superior when combined with calcium arsenate than when used alone or in combination with either lead arsenate or

nicotine. Used alone or combined with nicotine, the mixture was somewhat inferior to standard materials.

The foliage on plots treated with this mixture, with and without the various insecticides, was excellent. There was no trace of burn or "yellow leaf", and this mixture was considerably superior in this respect to the corresponding lime-sulphur sprays, and particularly so to the lime-sulphur arsenical combinations.

Aluminium sulphate and Lime-sulphur Mixture.

This mixture was used during five seasons and in about twenty orchards.

Combined with each of the three insecticides, the mixture gave results in insect control quite similar to the corresponding lime-sulphur sprays.

As a fungicide this mixture was greatly influenced by the particular insecticide used, being much superior when combined with either lead arsenate or calcium arsenate than when used alone or in combination with nicotine. Used alone or combined with nicotine, the mixture was somewhat inferior as a fungicide to corresponding lime-sulphur sprays, while the mixture combined with either of the arsenicals was a strong fungicide, quite equal to lime-sulphur lead-arsenate. In some tests the mixture with one arsenical was somewhat inferior to corresponding lime-sulphur sprays, in others the two types of spray were about equal in value, and in still others the mixture with arsenicals was markedly superior to lime-sulphur with arsenicals. There was some evidence the lime-sulphur was stronger as an immediate fungicide, that the mixture was fungicidal over a longer period, and that the variations in results were due to which of these particular properties happened to be more needed in the particular orchard concerned.

The foliage on plots treated with this mixture was, for the most part, excellent. The leaves were larger and of a darker green color than on corresponding lime-sulphur plots, and there was an absence of typical lime-sulphur injury, which, in most of the experiments, was in marked contrast to the lime-sulphur. The mixture used alone or with nicotine was very safe on apple foliage. Used in combination with lead arsenate there was some injury from arsenical burning in some of the experiments. In combination with calcium arsenate the mixture was very safe, but in this connection it was found that following the last spray of the season there were traces of "yellow leaf" produced in a few of the experiments on a few of the apple varieties. Where calcium arsenate was used in excess of the amount described, this trouble was accentuated. Injury of this type, however, was trivial as compared with the lime-sulphur injury on the lime-sulphur plots.

There are certain features in connection with this mixture which should be mentioned. Hydrogen sulphide gas is produced in the preparation of this mixture, and the concentration of this gas in the spray tank is quite considerable. This gas has poisonous properties very similar to that of carbon monoxide, and persons using this mixture should be warned not to breathe the concentrated gas inside the tank without previously ventilating it. Also, this gas has somewhat of a corrosive effect on the valve and valve seat of some of the commercial spray machines, and therefore

parts should be installed of material not subject to corrosion. It should be noted that this spray is very adhesive, being only very slowly removed by rains. Also this spray is useless as a dormant application against scale insects, but is equally effective as lime-sulphur in the summer control of European red mite.

Some Conclusions.

Under Nova Scotia conditions it is obvious that the zinc sulphide and iron sulphate mixtures are not worthy of further consideration, though the iron sulphate mixture would probably be satisfactory in districts where high fungicidal properties are not so important. The aluminium sulphate mixture, however, is of decided promise and it has been tentatively recommended to Nova Scotia fruit growers, many of whom have been satisfactorily using the mixture during this present season.

The Biological Control of Noxious Weeds.

Dr. R. J. Tillyard, Canberra, Australia.

I. The general problem.

The general problem of the control of noxious weeds by biological methods may be briefly stated as the inverse of the problem of the biological control of the insect enemies of economic plants. In the latter case, the host plant is regarded as beneficial to man, and therefore any insect which attacks it is classed as injurious, and the parasites of that insect, in their turn, are classed as beneficial. But this relationship is not innate in these organisms; it is only a statement of their actual relationship to the manifold activities of Mankind. Now, a weed has been aptly described as a plant out of place; in other words, it is a plant which has become injurious to the economic scheme as devised by Mankind. Logically, then, any insect or other organism which attacks a weed must be regarded as beneficial to Mankind, and any parasite of such an insect must be regarded as injurious in so far as it tends to check the good work being done by the phytophagous insect.

II. Safeguards.

The special feature of the problem is the obvious danger of the method at first sight. In dealing with this feature, I wish to say that, in my opinion, the real danger does not lie in the method, which is strictly logical and scientific, but in our colossal ignorance of the habits and psychology of the immense number of species of insects which inhabit this earth. We need far more accurate information of the relationships of phytophagous insects to their host plants, of the causes which lead to changes in the selection of food plants by different species, and more especially of the underlying principles of differentiation of the so-called physiological races of species. Until our knowledge along these lines is far fuller than it is at present, we must use the new method with full appreciation of its inherent dangers, and must devise such mechanical safeguards and strict regulations as may be found necessary for the safety of the country concerned.

In New Zealand, where I was instrumental in starting this work with a view to checking the alarming increase of such terrible weeds as Blackberry, Ragwort and Gorse, an amicable working arrangement with the Department of Agriculture appears to have satisfactorily solved the problem. For the purposes of the Noxious Weed work, the Cawthron Institute insectaries are regarded as a quarantine station, and all insects introduced into them from abroad are regarded as having been introduced

under a restricted or quarantine permit. That is to say, they may only be liberated, reared and studied in these insectaries, and cannot be put out into the open until such time as the work is far enough advanced to allow of an open permit being granted by the Minister. In the meantime, it is of the utmost importance that no accidental escapes should occur, and thus we have come to adopt a new type of quarantine insectary, in which the principles of a baffle-chamber entry with insect trap attachment, and double or even triple protection of the actual enclosure, have been put into operation. The main quarantine insectary at the Cawthron Institute is about fifty feet square, divided into sixteen sections, each capable of being irrigated from a separate source, but all entered by a single baffle-chamber to which is also attached a quarantine store-room. The baffle-chamber has interlocked doors with electric bell controls, so that, when one is open, the other is automatically shut. By raising the roof and making it mainly of glass, it has been possible to give good lighting throughout with adequate ventilation in all directions. The whole structure is protected by tightly drawn quarter-inch wire-netting, and the actual quarantine enclosure lies four inches inside this protection, the sides and roof being all formed of sixty-mesh phosphor-bronze gauze.

The regulations governing the issue of an open permit place the whole of the work under an expert committee which holds regular sittings in Wellington, and to which the research workers report quarterly. The actual research is in the nature of tests as to the capacity of any given stage of a phytophagous insect to damage any plant of economic importance to New Zealand. A list of such plants has been drawn up, and carefully controlled tests must be carried out on every one of them. Large supplies are needed for this type of work, for each test must involve a sufficient number of specimens, together with controls, to satisfy the committee that the behaviour of the insect is really what the test appears to indicate. Every stage of the insect, from the newly hatched larva to the imago, must be adequately tested. Further, two main types of test have to be carried out, viz. (1) oviposition tests, and (2) starvation tests. The discovery, at any stage, that the tested insect will either oviposit on a plant of economic importance or eat it, automatically stops the research, and the supply of that particular species on hand has to be destroyed.

It will thus be seen that an insect has to be very highly specialized in its food habits to pass through this tightly drawn net of regulations and arrive at the stage when the committee may consider the question of an open permit for liberation. As a result of the first eighteen months work in New Zealand, only a single insect has so far succeeded in passing these tests completely, viz. the Cinnabar Moth, *Tyria jacobaeae,* which is a remarkably effective control of Ragwort in parts of Europe.

It remains to be added as an obvious corollary that all parasites of the insect to be used must be rigidly excluded. In the case of *Tyria,* the insect was introduced in the pupal stage, and every parasite emerging from the pupae was immediately destroyed. The clean adults were paired in special breeding cages inside the insectaries, and by this means a New Zealand race of this moth entirely free from its natural parasites is now being liberated for the control of Ragwort. It still remains to be seen what parasites native to New Zealand will attach themselves to the new introduction; but in the

meantime, the moth may be expected to go ahead vigorously, at least for some years, and should eventually prove an enormously powerful ally to man in his fight against Ragwort in New Zealand.

III. Prickly Pear work in Australia.

I propose here to give you a general summary of the greatest experiment ever initiated in Biological Control of Noxious Weeds, viz. the work of the Prickly Pear Board in Queensland and New South Wales. This work was begun eight years ago under the direction of Professor Harvey Johnston, of Queensland University, after many years' experimentation with chemical and mechanical means had failed. At that time, there were sixty million acres of land unter the pest pear in Queensland and Northern New South Wales, and the pest was increasing at the rate of a million acres a year. Australia had to face the nightmare of a future in which the whole of the subtropical and warm temperate belt of the Eastern States might become a wilderness of dense cactus, with a few walled cities holding out against the invader. Even the most conservative of scientific men quailed at such a prospect, and it was undoubtedly the terrific menace that finally brought the method of Biological Control forward as the only possible method of fighting the peril. During the succeeding years, the work was under the scientific control of Mr. J. C. Hamlin, Mr. W. B. Alexander, and finally of Mr. Alan P. Dodd, who has held the position for the last three years and is doing this difficult work remarkably well. The sum avaible for this tremendous piece of research is only £12,000 per annum, of which one half is contributed by the Commonwealth, with two representatives on the Board, and one quarter by each of the States concerned, with one representative each on the Board.

The main laboratory and insectaries of the Board are situated at Sherwood, near Brisbane, and there are substations at Westwood and Chinchilla in Queensland and at Gravesend in the North-west of N. S. W. The total staff employed is about forty, but by no means all of these are trained entomologists.

The first work carried out was done in the United States, from Florida across to Texas, in Central Amerika, Peru, Chile and Argentina. In fact, wherever prickly pear of the genus *Opuntia* was known to occur, insects feeding on it were sought for. Preliminary tests carried out showed that none of the cactus feeding insects were likely to attack any plants of economic importance. Supplies had to be reared and freed from all parasites, and then shipped to Australia. I believe only two errors occurred in this work. The first consignments of the large Longicorns of the genus *Moneilema* failed to get going in Australia owing to the unwitting introduction of an egg-parasite. Fortunately this was discovered at Sherwood, and the whole of the material was destroyed, leaving the way free for later introductions free of egg-parasites. The other error proved to be a fortunate one. A smal red spider, afterwards described as *Tetranychus opuntiae,* was *accidentally* introduced in one consignment and got out into the field. It is proving to be one of the most destructive enemies of prickly pear known. Althought morphologically inseparable from the common red spider of orchards and gardens, it is yet quite incapable of feeding on anything but

Opuntia, and is therefore a very important example of a physiological race which has been arbitrarily given a distinctive name.

The first insect to be tried out was the common Cochineal Insect, *Dactylopius indicus*. This insect entirely destroyed about five thousand acres of the species *Opuntia monacantha*, but died out owing to its inability to feed on the commoner species of pest pear, *Opuntia inermis* and *O. stricta*. Consequently, other species were introduced, but the only one which would attack the pest pear was *Dactylopius tomentosus*, introduced in 1920. This insect is very deadly on the pear, especially where it is most dense. It is probable that it carries a virus with it, for the effect of the attack is frequently out of all proportion to the number of insects. More than thirty thousand cases of this insect have been distributed in Queensland alone, and the mass effect on the densest infestations of pear has been tremendous.

The other insects acclimatized successfully in Australia and playing the most important part may be divided into two groups, viz. Pyralid moths of the genera *Cactoblastis*, *Mimorista* and *Melitara*, and the large Coreid bugs of the genus *Chelinidea*. By far the most effective of all these is the species *Cactoblastis cactorum* from the Argentine, of which about nine million have been distributed to date. This moth was brought in by Alan Dodd in 1925, and it is now attacking the common species of pest pear over very large areas. The larvae live in colonies of forty or more and tunnel right into the hard butts of the pear, causing tremendous damage. As it is two brooded and even partially three brooded, what little pear survives the attack of the first brood is entirely wiped out by the second.

The species of *Melitara* and *Mimorista* have been distributed to the number of about one and a half million, but are considered of less importance now that the tremendous effectiveness of *Castoblastis* has been proved.

Of three species of *Chelinidea*, the most promising is *Ch. tabulata*, of which over 100,000 have been distributed. These bugs do not kill the plant, but their mass attack causes great damage and prepares the way for the more deadly insects.

Not much success has attended the attempt to acclimatize the large wingless Longicorns of the genus *Moneilema*, owing to the difficulty of rearing them under confined conditions and carrying out the prescribed tests. But once this difficulty can be overcome, these insects have great potential value for the destruction of pear.

An interesting point to note is that very little damage has so far been done to the attacking insects by native parasites. Our old friend *Cryptolaemus montrouzieri*, known to every economic entomologist for its value in controlling mealy bug in California, has appeared as an enemy of *Dactylopius*, but the damage caused by it is not very great, as it is naturally too slow in starting. A species of *Habrobracon* is causing small losses to *Cactoblastis*, but scarcely affects the mass result of the attack of this fine insect.

In the opinion of Alan Dodd, the present condition of the experiment can only be viewed with great enthusiasm. He states that it seems

highly probable that the second worst species of pear, *Opuntia stricta,* occupying several million acres of land, will be reduced to negligible proportions within ten years from now, while the outlook for complete control of the worst species, *O. inermis,* is also highly promising, though the attacking insects are not expected to yield spectacular results, but rather to reduce the pest slowly and insidiously over a term of years. What is certain is that the method of biological control has proved the only method of attack on this tremendous problem, and that what was once a hopeless position is now viewed by everybody concerned with the highest favour as likely to yield a permanent solution of the problem.

IV. Noxious Weed work in New Zealand.

The New Zealand work has for its objectives the discovery of suitable insect controls of Blackberry, Ragwort and Gorse, as well as several lesser weeds. The work was begun through a grant of £4000 a year for five years, one-half being contributed by the Empire Marketing Board, one-fourth by the New Zealand Government, and one-fourth by the Cawthron Institute in Nelson. A special grant of £2000 enabled the Cawthron Trustees to build a suitable insectary and attached laboratory close to the main Institute. Supplies from Europe were secured through the help of Rothamsted Experimental Station, and Dr. A. D. Imms will tell you about that end of the work in his address which is to follow this. At the present time, the moth *Tyria jacobaeae* has passed successfully through all its tests and is being liberated for control of Ragwort. The weevil *Apion ulicis* appears to have passed its tests satisfactorily, but the problem of getting it fully acclimatized to the new conditions of flowering of gorse in New Zealand has not been completely solved, and no liberations of this promising insect have yet been made. The worst weed in New Zealand is undoubtedly Blackberry, of which it has been remarked that, on the west coast of the South Island, there is only one bush, but that bush is 200 miles long. Both *Thyatira batis* and *Habrosyne derasa* have been tested and turned down owing to the larvae attacking other *Rosaceae.* Many other promising insects are being tested, the most destructive being apparently the stem-boring Buprestid *Coroebus rubi* from Southern Europe. This Blackberry problem is complicated by the closeness, botanically, of the economically valuable raspberry and loganberry, and it seems likely that final success will only be attained by working out successfully some simple spraying schedule to protect these crops in Blackberry districts. The total annual value of the raspberry and loganberry crops in New Zealand is very small compared with the losses due to Blackberry; but nevertheless, the policy laid down for this line of research is to discover insects that will attack Blackberry only, if such exist, and, in the event of these not being found, to be guided by the opinion of Parliament as to what risks might legitimately be taken with insects which might attack other species of *Rubus* or possibly Roses. Owing to its central position in the *Rosaceae,* Blackberry presents a problem altogether much more difficult than that of any other of the bad weeds of Australia and New Zealand.

V. Future work in Australia.

With the foundation of a Central Entomological Research Station at the new capital, Canberra, and substations in various States, it is intended that research concerning the possibility of biological control of various noxious weeds shall be extended greatly in Australia. The first weed to be studied will be St. John's Wort, *Hypericum perforatum*, of which there are a quarter of a million of thickly infested acres in North-eastern Victoria. This apparently harmless weed grows to immense size in that district, and the writer has dug up huge plants with tubers a foot across and more than fifty main stems growing up from each, up to five and a half feet in height. The present mode of destruction is to salt the land at a cost of £5 per acre, but this deteriorates the value of the soil, and after three or four years the seeds come up as thick as ever. It is clear that the control of St. John's Wort in Australia is insoluble except along biological lines, and therefore the attempt will be made. Many insects are known to feed on this weed, and it is so specialized that it may be reasonably expected that a fair number of them will pass the requisite tests and form the basis of future work in the open.

Australia possesses so many other bad weeds that a big staff would be required to deal with them. A start may soon be made with the problems of Saffron Thistle *(Kentrophyllum lanatum)*, Star Thistle *(Centaurea calcitrapa)*, Bathurst Burr *(Xanthium spinosum)*, Patterson's Curse or Viper's Bugloss *(Echium vulgare)* and a number of others.

In conclusion, I wish to emphasize the fact that biological control of Noxious Weeds has been successful so far both as regards Lantana in Honolulu and to a large extent as regards Prickly Pear in Australia, that it is the only practicable method of dealing with immense areas of weeds in sparsely populated countries, and that, quite apart from the economic value of the work to the country concerned, the extensive researches which must be carried out before any permits for liberation can be granted, will probably solve a very large number of intensely interesting and important problems in the pure science of the relationship of phytophagous insects to their host plants which would otherwise never be solved at all.

Remarks on the Problem of the Biological Control of Noxious Weeds.

A. D. Imms, D. Sc.,

Rothamsted Experimental Station, Harpenden, England.

In its natural or original habitat an animal or plant is ordinarily kept within limits of abundance by the interaction upon it of biological and other agencies. If, on the other hand, such an animal or plant finds a home in another country where the environment is favourable, but where those agencies which control it in its original habitat are wanting, the probability is that the animal or plant, as the case may be, will multiply and spread to such a degree as to assume the status of a pest. Examples of such occurrences are familiar to all who have followed the subject. Biological control in such instances aims at the restoration of the "balance of nature" or of a condition of natural equilibrium with respect to the pest organism in its new environment.

The present paper is solely concerned with pest-plants and possible means of their biological control. In parts of the world certain introduced weeds have either resisted all attempts at cultural or chemical methods of control or such methods have proved to be economically impracticable. Examples are well known where weeds have invaded and colonised land even to the extent of rendering it useless. This has happened with *Lantana* in the Hawaiian Islands and other parts of the world, with prickly pear and other plants in Australia and with blackberry, ragwort, etc., in New Zealand. The first attempt to cope with such a situation was made in the Hawaiian Islands, where it was met by the introduction and colonization of a number of species of insect enemies of *Lantana* from Mexico (Perkins and Swezey, 1924). The beneficial effects of these insects, more especially in prevention of seeding, have largely checked that plant from re-infesting areas previously cleared. At the present time encouraging results are being obtained in the biological control of prickly pear in Australia by introducing into that country suitable *Opuntia*-feeding insects from North America (Dodd, 1927).

In any attempt to control pest-plants by the introduction of insects which live at the expense of such plants, four "principles" need emphasis.

1. There is abundant evidence that alien insects, which have entered countries unaccompanied by their natural parasites, can exercise an immense and destructive effect on cultivated crops. There appears to be no valid reason why, similarly, suitable types of insects introduced free from their natural enemies should not likewise exercise a destructive effect upon noxious alien weeds, given an environment favourable to the colonization

of such insects. It is this principle that is fundamental in problems of the insect control of weeds.

2. The second principle involved is that any insects utilised in the control of pest plants must be species which are known to be confined to a very restricted range of host plants and unlikely, in a new environment, to infest important economic plants also.

With certain plant-hosts such as *Opuntia* the likelihood of insects which feed upon them resorting to other kinds of plants is remote. Insects feeding upon plants of such unusual characteristics and endowed with acrid juices, along with other specialised physiological properties, exhibit so peculiar and rigid an adaptation to their particular mode of life that they are unlikely to infest plants botanically unrelated and with entirely different physiological attributes. With plants of the natural order *Rosaceae* for example, on the other hand, there is always the looming possibility that, in a new environment, insects which normally feed upon a single genus or species will infest allied or other economic plants.

3. In contingencies where a pest-plant has close allies of economic value the method of insect control requires exceptionally cautious procedure. In such instances biological control is beset with manifold difficulties, and lack of foresight may result in the remedy being worse than the disease.

If insect control of such kinds of pest-plants commends itself as a feasible proposition recourse should be rigidly confined, in the writer's opinion, to the introduction of species of insects which are of specialised habits and behaviour. Root-borers, stem-borers and internal seed- or fruit-feeders are preferable to leaf-feeders since their economy is usually more delicately adjusted to specific hosts, and for that reason probably less liable to change in a new environment. It is noteworthy that recent experiments by Davies (1928 A) with leaf-feeding larvae of the moth *Habrosyne derasa* have shown that, although the usual food-plant of this species is blackberry, it exhibited capability to feed upon loganberry, raspberry, rose and apple, and to a lesser degree upon plum, cherry and pear.

4. Any insects likely to prove of value in the biological control of pest-plants require exhaustively testing, in the first instance, with reference to the possibility of their feeding upon plants other than the particular host in view. Such experiments require to be conducted, firstly in the native country of such insects and, if these tests prove negative, further experiments are necessary under the new environmental conditions where it is proposed to colonise the insects.

Experiments of this character may require to be framed so as to involve several possibilities. In the case of *Habrosyne derasa* previously alluded to feeding experiments were carried out (a) with newly-hatched larvae, before they had fed upon their usual food-plant and so become "adapted" to it: (b) with halfgrown larvae previously fed upon their usual food-plant. With other insects, *Apion ulicis* of gorse, for example, it proved desirable to design experiments not only to test a range of hosts upon which egg-laying and larval development might conceivably occur, but also with reference to the feeding habits of the adult insects both before and after hibernation (Davies, 1928).

I. Host Selection by Insects in Relation to Weed Control.

It is of prime importance in the biological control of weeds to be in a position to judge the possibility of a particular species of insect extending its feeding propensities to plants other than the kind which it is already known to attack. Numerous instances are to be found in entomological literature of more or less polyphagous insects feeding upon plants from which they were not previously recorded. Examples of this character seem to have little direct bearing upon the problem of noxious weed control, for the reason that polyphagous insects are not likely to be countenanced in such schemes. Instances of unrecorded hosts of insects long known to feed upon a single species, genus or a restricted group of plant genera are, however, of very direct concern and a few examples illustrating tendencies of this nature may be enumerated. Thus, larvae of *Vanessa* butterflies such as *io, c-album* and *urticae* which are more especially associated with nettle *(Urtica)* are known to be able to feed upon hop *(Humulus)*, which, however, is closely related to their usual host-plant. A more striking example is afforded by *Pyrameis cardui*, an insect of almost cosmopolitan range, which feeds more especially upon *Carduus* and *Urtica*, but has recently been recorded in Poland as feeding upon *Lupinus angustifolium* and upon peppermint and soy beans in Michigan, U. S. A. The Pyraustid moth *Notarcha ruralis*, which normally feeds upon nettle, has been recorded in Franc as infesting maize. The Lycaenid *Cyaniris argiolus* which feeds upon the young leaves and flowers of *Ilex, Hedera, Rhamnus* and *Cornus* has been observed in Finland boring into the unripe fruit of black currants. Again, the larva of *Thecla echion* which feeds upon the flower-heads of *Lantana* in Mexico has been noted to resort occasionally to the fruit of the egg-plant in the Hawaiian Islands. This insect, it may be added, was introduced along with others from Mexico into the Hawaiian Islands as a contributory aid in the control of *Lantana*, but its apparent change of habit had not led to any serious consequences. Mention needs also to be made of the moth *Tyria jacobaeae* which normally feeds upon certain species of *Senecio*, rejecting others. An instance has recently come to notice of its feeding upon a plant of *Sonchus* which was growing in an insectary wherein the larvae were confined along with plentiful supplies of *Senecio jacobaeae*. Theobald (1903) records this same insect feeding upon potato foliage, and in view of this fact experiments were conducted by H. C. F. Newton at Rothamsted with particular reference to this trait, but only negative results were obtained, the larvae refusing potato and finally dying of starvation. Two other examples may be quoted, but in both instances the insects concerned are of a more pronounced polyphagous habit than those previously enumerated. Thus, Theobald (1926) has recorded the leaf-hopper *Typhlocyba lethieryi* for the first time from hops, the insect usually occurring on trees, more especially elms. The other example is afforded by the Capsid *Plesiocoris rugicollis*, which commonly affects *Salix* and less frequently *Alnus, Myrica* and *Corylus*. In recent years it has developed the habit of feeding upon apple and also upon currants and in England it has become a serious economic pest.

Many other instances analagous to those quoted above could be collected and in such examples two features appear to be significant.

(1) The insects concerned exhibit a markedly restricted host-preference; (2) they live externally upon their plant-hosts, feeding upon the foliage or flowers and are neither root-borers, stem-borers nor internal seed-feeders. The habit of sporadically resorting to an unusual food-plant is probably common to almost all leaf-feeding insects, and even more striking examples are known where insects were subjected to experimental conditions which excluded access to their usual food-plants (vide Dumont, 1928). From the economic standpoint these facts are of little significance unless the habit becomes definitely established and repeated in successive generations.

Experiments conducted by Marchal (1908) with the Scale insect *Coccus (Lecanium) corni* resulted in his being able to induce the insect to transfer from peach *(Amygdalis persica)* and feed upon false acacia *(Robinia acacia)*. Only certain of the larvae resulting from eggs laid on the new host were able to adapt themselves, but in the following year their progeny had so completely accepted the plant, that transference of individuals back to peach resulted in it being impossible to rear them to sexual maturity. Certain interesting experiments conducted by Schroeder are quoted by Bouvier (1922) as follows: — "The larvae of the willow Chrysomelid *(Phratora vitellinae)* feed normally on the leaves of a willow *(Salix fragilis)* which has leaves whose lower surface is smooth. They attach themselves to this lower surface, attacking the epidermis to reach the parenchyma, and skeletonize the leaves. Some young larvae were established by Schroeder (1903) upon a willow with downy leaves, *Salix viminalis*. They adapted themselves without difficulty, cutting and pushing aside with their heads the long pilose clothing of the lower face of the leaves and forming with it and with the skin of this surface a sort of blanket which covered them completely. These larvae devoured the tissue of the leaves, and one of them made a mine three centimetres long. The adults coming from these larvae deposited 127 layings on *S. viminalis* and 219 on *S. fragilis*. In the course of successive generations, all raised on *S. viminalis*, the number of layings placed upon this species increased progressively, while those laid on *S. fragilis* diminished. In the fourth generation Schroeder obtained fifteen layings, all upon *S. viminalis*, and the larvae coming from these layings adopted the mining type of life". "It is evident", adds the author, "that similar modifications are produced in nature, especially when the normal foot plant is lacking." Heslop Harrison (1927) published the results of certain field experiments with the gall-forming saw-fly *Pontania salicis*. He removed a strain of this insect which is locally adapted to *Salix phylicifolia* to a district where various species of *Salix* grew, and the insects were allowed to oviposit unhindered in the open. They showed a marked preference to adopt *Salix andersoniana* to the comparative neglect of the very closely allied original host *S. phylicifolia*, a feature that was particularly evident during two successive years. In other experiments he found that a strain of the same saw-fly from *Salix andersoniana* brought to another locality where only *Salix rubra* was available became adapted to that host. Later, when plants of *S. andersoniana* were etablished in that locality in proximity to *S. rubra* the former species of willow remained entirely free from the galls of this saw-fly. He further mentions that the latter, in its reaction to a changed food-plant, shows corresponding colour differences. Mention needs

also to be made of Pictet's experiments with larvae of *Lasiocampa quercus,* which feed upon deciduous trees and bushes. When placed upon *Pinus* many of them died and those which survived fed by biting into the parenchyma at the extremities of the pine needles. In the second generation the insects became adapted to the new diet to the extent that they either starved when offered leaves of deciduous trees, or they only attacked the apices of the leaves which they hollowed out in a manner similar to that performed by larvae of the previous generation. Without discussing the question of the significance of such experiments as a demonstration of the inheritance of acquired characters, the data they afford do at least indicate that it is possible for an insect to become rapidly adapted to an unusual food-plant to the extent of partially or completely rejecting its original host — at least for the limited period over which the experiments were conducted. Field observations made in recent years on the behaviour of *Plesiocoris rugicollis,* as already mentioned, strongly indicate that this insect has become adapted to a new food-plant. Similarly, according to Theobald (1926), *Vanessa io* appears every year to become more and more frequent in hop gardens, where its conspicuous larvae cause some amount of defoliation. It appears possible, in this instance, that a biological strain has developed which utilises hop in preference to its more usual food-plant, the nettle.

The foregoing observations serve to emphasise possible risks attending the application of insect control to noxious weeds. They are, however, far too few in number to warrant any general deductions to be drawn therefrom and it by no means follows that analagous behaviour would necessarily result with a vast number of other insects. In this connection it is noteworthy that in the extensive experiments by Dumont, using carrot roots as a compulsory food for lepidopterous larvae, a much larger number of the species tested either refused to feed or succumbed after a variable period of feeding, than those which completed their metamorphoses and produced imagines.

II. Noxious-Weed Control in New Zealand.

Blackberry *(Rubus fruticosus),* Ragwort *(Senecio jacobaea),* Gorse or Furze *(Ulex europaeus)* and other introduced plants constitute a menace to agriculture in parts of New Zealand. It is possible that a solution of such problems may rest in the attainment of a condition of equilibrium by the colonisation, on a scientific basis, of certain elements of the insect fauna which assist in keeping such plants in check in their original environment. The application of biological control measures as an attempt to meet the situation has been strongly urged by Dr. R. J. Tillyard and the necessary financial provision has been made by the Empire Marketing Board in conjunction with the New Zealand Government and the Cawthron Institute at Nelson (N. Z.).

Since the majority of the insects it is desired to introduce into New Zealand are native to Europe, a proportion of the funds has been allocated to the Rothamsted Experimental Station which is co-operating, for the time being, in the provision of supplies. Work at the Rothamsted Station *) is

*) W. M. Davies, Ph. D., was appointed assistant entomologist in charge of the work at Rothamsted in 1927 and upon his resignation to take another post, he was succeeded by H. C. F. Newton, B. Sc., A. R. C. S.

concentrated in the first instance upon investigating the life-history and behaviour of those insects it is desired to utilise. This is followed by feeding tests of the nature outlined in § 4 and, provided such tests are of a negative character, sufficient stock of a species is either bred or collected and finally shipped out to New Zealand. Since the procedure adopted on arrival of the insects in the latter country has already been described, it is unnecessary to make further mention here. *)

Blackberry. — The great severity of the menace of blackberry to cultivation in New Zealand has become a pressing problem. The chief difficulty in attempting some measure of restraint by the application of biological control is the position of the genus *Rubus* in the natural order *Rosaceae* to which so many of the most valuable economic plants belong. The risk of blackberry-feeding insects turning to one or more of these botanically related plants is enormously greater than with species feeding upon *Lantana* or *Opuntia*, and consequently precautions against such an eventuality require to be exceptionally rigid.

Among various insects that have been considered in relation to their possible biological effects upon this plant, one of the most promising European species is the stem-boring Buprestid beetle *Coraebus rubi* (vide Genieys, 1927). In addition to blackberry, however, in attacks Frau Karl Druschki and similar roses and since it is not native to Britain, the work of obtaining supplies is being undertaken at Antibes near Menton, where it is prevalent. The most convenient method of collecting, up to the present, has been to secure infested rose-stocks during the winter months and in February ship those which contain the insect in its last larval instar out to New Zealand. In addition to this procedure special planting and individual infection of blackberry stocks is being arranged for.

The habit of this species infesting certain types of roses, although not necessarily very disturbing in view of the overwhelming importance of blackberry control, precludes the possibility of any attempt at practical utilization being made of the insect until its behaviour has been exhaustively investigated.

Ragwort. — As this weed is poisonous alike to horses and cattle in New Zealand, where it takes possession of large areas of both good and waste land, the problem of its future control is important. The plant is attacked in Europe by larvae of the moth *Tyria jacobaeae*, together with those of species of the genus *Homoeosoma* and also by beetles of the genus *Longitarsus* and certain Diptera, etc. The most vigorous attack is by *Tyria jacobaeae*, which has the further advantage in that it appears probable it would become permanently double-brooded under New Zealand conditions. This species, when reared quantitatively in captivity, requires abundant space to avoid overcrowding and a marked consequent tendency to disease, while the breeding cages need frequent sterilization by thorough washing with dilute formalin. Mortality in the pupal stage is also heavy and careful treatment is essential. With these precautions large numbers of this insect have been bred at Rothamsted and collected elsewhere in the field. Collected material, however, has especial liability to be parasitised, and the

*) See "Insect Control of Noxious Weeds". New Zealand Journ. Agric Feb. 1927.

species has a long list of insect enemies that are known to attack it. During the year 1928 about 16,000 pupae are being sent to New Zealand, besides approximately 20,000 eggs.

Gorse. — The problem of gorse control in New Zealand is a special one. The plant is of value in supplying nitrogen to the soil and also, when young, in affording fodder for sheep. Its eradication is neither desired nor aimed at, only means of preventing its further spread by seeding being deemed necessary. An important European enemy of gorse is provided in the weevil *Apion ulicis,* whose larvae live at the expense of the seeds. A survey carried out by Davies (1928) by means of random samples of gorse pods obtained from 62 localities in Great Britain proved that the insect heavily infested the pods and in one locality as high as 92 % infestation was found. Special attention has been given to the possibility of the *Apion* attacking economic plants of the leguminous tribe, but it was not possible to obtain oviposition in the pods of any species other than gorse. In addition to oviposition tests, the adult insects showed no ability to feed and thrive on any other leguminous plant either before or after hibernation. The species appears to be only lightly parasitised in the field, a 4% parasitism by the Chalcid *Splintherus leguminum* Ratz. being observed by Davies. Large shipments, usually at the rate of about 5,000 adult individuals per consignment, have been made at various times of the year. In the event of this insect failing to acclimatise itself in New Zealand, the possibility of utilising the moth *Laspeyresia ulicitana,* whose larvae similarly attack the pods of gorse, presents itself as a possible alternative.

Method of Shipping insects to New Zealand. — The length of the voyage from England to Wellington, including passage through the tropics, has led to the adoption of cool storage as the most convenient method of transporting insects. Through the courtesy of the New Zealand Shipping Co. and of Messrs. Shaw Savill & Albion Co. facilities were arranged for placing the insects in the vegetable room in their vessels, where the temperature ranges from 34° F to 38° F or a little higher. The insects are confined in stout wooden boxes measuring, as a rule, 12 in. × 8½ in. × 9 in. and generally each box is provided with a small gauze-covered panel to give ventilation. On the whole, for most insects, steam-sterilised sphagnum moss has been found a satisfactory packing material, since it has the property of withholding moisture for considerable periods and, at the same time, of not encouraging growth of mould. In the transmission of *Coraebus rubi* root-stocks of rose containing larvae of this insect were packed with ordinary moss instead of sphagnum. Pupae of *Tyria jacobaeae* and of other insects are packed between layers of moistened sphagnum or of "peat moss", while the eggs of *Tyria* were sent on portions of the food-plant which were suspended in the box with moistened sphagnum below. At first *Apion ulicis* were sent as adults, 2,000 to 5,000 per box, the latter being provided with a layer of moistened sphagnum moss and shoots of the insects food-plant were also enclosed. It was subsequently found desirable to confine the weevils in batches along with their food-plant in muslin bags, instead of leaving them free in the box: this procedure allows of more convenient handling on arrival at their destination.

These methods are to a large extent experimental in the present stage of the work, and much naturally depends upon the condition of the transported insects on arrival at the New Zealand end, where special provision is made for the reception of each consignment.

Literature.

Bouvier, E. L., 1922. — The Psychic Life of Insects. London (English translation by L. O. Howard).

Davies, W. M. 1928. — The Bionomics of *Apion ulicis* Först. (Gorse Weevil), with special reference to its role in the Control of *Ulex europaeus* in New Zealand. Ann. Applied Biol. XV, pp. 263—286.

id., 1928 A. — Notes on the feeding habits of *Habrosyne derasa* L. (Lepidoptera). Bull. Entom. Res. XIX, pp. 267—270.

Dodd, A. P. 1927. — The Biological Control of Prickly Pear in Australia. Bull. 34. Council for Sci. and Indus. Res. Australia.

Dumont, C. 1928. — Expériences sur la modification profonde du régime alimentaire de diverses chenilles. Ann. Soc. Entom. France, XCVII, pp. 59—104.

Genieys, P. 1927. — Un ennemi des rosiers, le *Coraebus rubi*. Ann. des Epiphyties, XIII, pp. 48—78.

Harrison, J. W. H. 1927. — Experiments on the Egg-laying Instincts of the Sawfly *Pontania salicis*, etc. Proc. Roy. Soc. London., Ser. B. pp. 115—126.

Imms, A. D. 1926. — The Biological Control of Insect Pests and injurious Plants in Hawaiian Islands. Ann. Applied Biol., XIII., pp. 402—423.

Marchal, P. 1908. — Le *Lecanium* du *Robinia*. Comptes Rendus Soc. Biol. Paris, LXV, pp. 2—5.

Perkins, R. C. L. & Swezey, O. H. 1924. — The Introduction into Hawaii of Insects that attack Lantana. Entom. Bull. 16. Hawaiian Sugar Planters Exp. Sta.

Theobald, F. V. 1903. — First Report of Economic Zoology, London.

id., 1926. — Notes on Insects feeding on Hops in 1925. Entom., LIX, pp. 129—130.

Sex-determination in Lecanium.

Professor Mathias Thomsen, Ph. D.,
Royal Veterinary and Agricultural College, Copenhagen.

(With 3 text-figures.)

Only a few years ago our knowledge of the biology of reproduction and especially of the sex-determination in Coccids was extremely scanty. As late as 1920 the well known German cytologist Hans Winkler in his book on parthenogenesis in the animal and vegetable kingdoms wrote as follows: "The Coccids are generally bisexual (i. e. gamogenetic as I would prefer to say). Heterogony does *not* occur, but parthenogenesis has been stated to take place in several species. A thorough systematic investigation of this question has not been undertaken, however; but the statement by Leuckart (1858) that the coccid genera *Lecanium* and *Aspidiotus* are parthenogenetic is found to this very day in text books, (cf. f. inst. Claus-Grobben 1917, p. 602), though it has never been verified in any way"*). So far Winkler. What we knew about the sex-determination of Coccids in the year 1920 can be summarized in a very few words.

In *Lecanium hesperidum* both Leydig (1854) and Leuckart (1858) had found only females and no sperm in the receptacle. In *Coccus* (i. e. *Pseudococcus* in our modern terminology) Leuckart always, and in *Aspidiotus* sometimes, found spermatozoa in the receptacle. Also Emeis in *Cryptococcus fagi* and Herberg in *Eriopeltis lichtensteini,* saw only female individuals and did not discover any sperm in their oviducts. In the light of later investigations, however, these statements cannot be considered absolute proof of the occurrence of parthenogenesis in these species. Winkler in fact terminates his chapter on the parthenogenesis of Coccids with the words: "Further investigations on this subject are much to be desired."*)

The very next year (1921) brought a paper by Franz Schrader, which, together with some other papers of his appearing in the following years, formed a detailed investigation of the sex-determination and cytology of the genus *Pseudococcus.*

In brief: he discovered that contrary to expectation *Pseudococcus* females were *not* able to reproduce parthenogenetically; virgin females isolated on their host plants failed to lay eggs, while the offspring of fertilized females consisted of both sexes in almost equal numbers. With regard to his interesting cytological results I must be content here with saying that the spermatogenesis showed very remarkable features, till that

*) Translated by M. Th.

time not met with in any other animal, and most reasonably interpreted by Schrader as meaning that all 10 chromosomes of the male contain "sex-chromatine", five of them representing X-chromosomes, the other five Y-chromosomes.

In the following years (1925—1927) Mrs. Hughes-Schrader, partly together with Franz Schrader, published investigations on another Coccid, *Icerya purchasi,* "the cottony cushion scale", which gave very interesting results too. Correcting earlier accounts by Pierantoni these authors gave clear evidence that the so-called females of *Icerya* are really all protandric hermaphrodites, a condition unique among insects, with the possible but very doubtful exception of *Termitoxenia.* Beside the hermaphrodites, true males exist which have turned out to be haploid and which originate from unfertilized eggs of the hermaphrodites. The males copulate with the hermaphrodites, the offspring consisting of hermaphrodites and sometimes a few males, but the hermaphrodites more often fertilize themselves, the offspring of isolated hermaphrodites being likewise mainly hermaphrodites and very few males. Spermatogenesis in the males proceeds almost along the same lines as in haploid Aleyrodids, i. e. with only one maturation division without further reduction of the chromosome number. It was to be expected that spermatogenesis in the — diploid — hermaphrodite would induce the reduction of the chromosome number in a normal way through two maturation divisions; this was indeed first thought to be the case. Further study revealed, however, that only exceptionally this course of development is followed. Nearly always haploid cells appeared at a very early stage in the development of the hermaphroditic gonad, although it proved impossible to ascertain the cytological mechanism of this reduction process. The haploid cells multiply, forming a haploid tissue in which subsequently spermatogenesis is carried out in a manner corresponding exactly with that in the haploid male.

The cytological and biological peculiarities of *Icerya* were found to be the same in insects procured from California, Italy and other countries.

These valuable studies of Mr. and Mrs. Schrader have proved of equally great interest for the cytologist and for the entomologist interested in the natural history of Coccids.

I now turn to my special topic: the genus *Lecanium.*

In most species of *Lecanium* (taken in its broad sense) males are exceedingly rare, in many indeed they have never been met with at all. The only European species in which males are said to be common by all authors is *L. coryli.* As I have already said, Leydig and Leuckart, in *L. hesperidum,* failed to find sperm in the females which reproduced abundantly. This of course was a strong indication of the occurrence of parthenogenesis in this species, though no proof.

Therefore my study of *Lecanium* began with *L. hesperidum.* It soon turned out that in this species two races occur, different in regard to reproduction as well as to the chromosomal mechanism connected with it. I have termed them the obligatory parthenogenetic and the bisexual parthenogenetic races; both of them I found in the greenhouses of the Royal Veterinary and Agricultural College of Copenhagen.

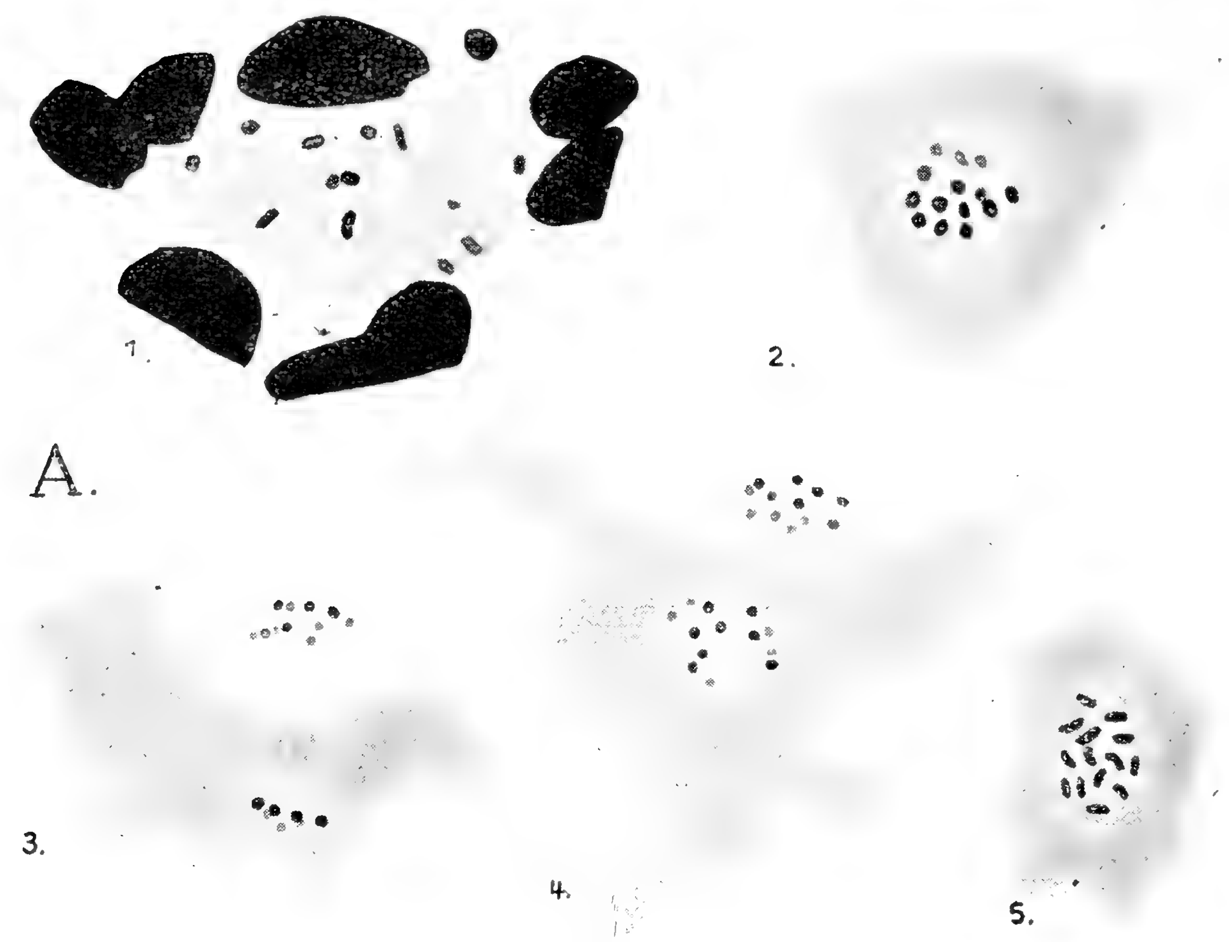


Fig. A.

Lecanium hesperidum, obligatory parthenogenetic race. 1. diakinesis, unpaired chromosomes. 2. metaphase of maturation division. 3. anaphase. 4. telophase, the diploid number is seen in the egg nucleus. 5. cleavage mitosis. (From Thomsen, 1927).

The first of them, the obligatory parthenogenetic race (or biotype in the sense of W. Johannsen), as the name implies reproduces only parthenogenetically. I have never found males, although thousands of individuals have passed through my hands. The cytological features of this strain will appear from fig. A. I have not been able to find any indication of a synapsis or of tetrad formation. In diakinesis (fig. A, 1) the diploid number of 14 small chromosomes appears and in the metaphase (2) the same number is very clearly to be seen. There is only one maturation division, being of course equational, 14 chromosomes passing to each pole (3, 4). The same number is easily seen in cleavage mitoses (5) and later somatic divisions.

This shows nothing very extraordinary, corresponding closely to the oogenesis of Aphids and several other organisms possessing obligatory parthenogenesis.

Let us turn then to the other biotype, the bisexual-parthenogenetic race. Here both sexes occur, but the females generally greatly outnumber the males. It seems that males of *L. hesperidum* have only been seen three times before (and parenthetically I might add that no satisfactory description of this stage yet exists). Isolated virgin females in all my experiments solely gave rise to females; I did not succeed in observing any copulation, however, so that the sex of the offspring of impregnated females could not be determined directly. There can be little doubt, however, that males must take their origin from fertilized eggs, seeing that they occurred in wild colonies, but never among the descendants of virgin females.

The main facts of the oogenesis are illustrated by fig. B, 1—7. During diakinesis (1) the chromosomes appear as cross-figures, double-chromosomes and typical tetrads which sometimes are seen to be haploid in number. The first metaphase (2) displays the haploid number of 7 big, double chromosomes with schematic distinctness, thereby differing most characteristically from the same stage in the obligatory parthenogenetic egg. During the first anaphase each of the daughter chromosomes divide, so that the egg nucleus and the first polar nucleus for a short time both possess 14 small chromosomes (3). The chromosome halves presently unite again and the metaphase of the second division shows 7 chromosomes (4). This division proceeds normally, the reduction of the chromosome number thus being accomplished. Almost at the same time the first polar nucleus divides, 3 polar nuclei now lying at the periphery of the egg (5).

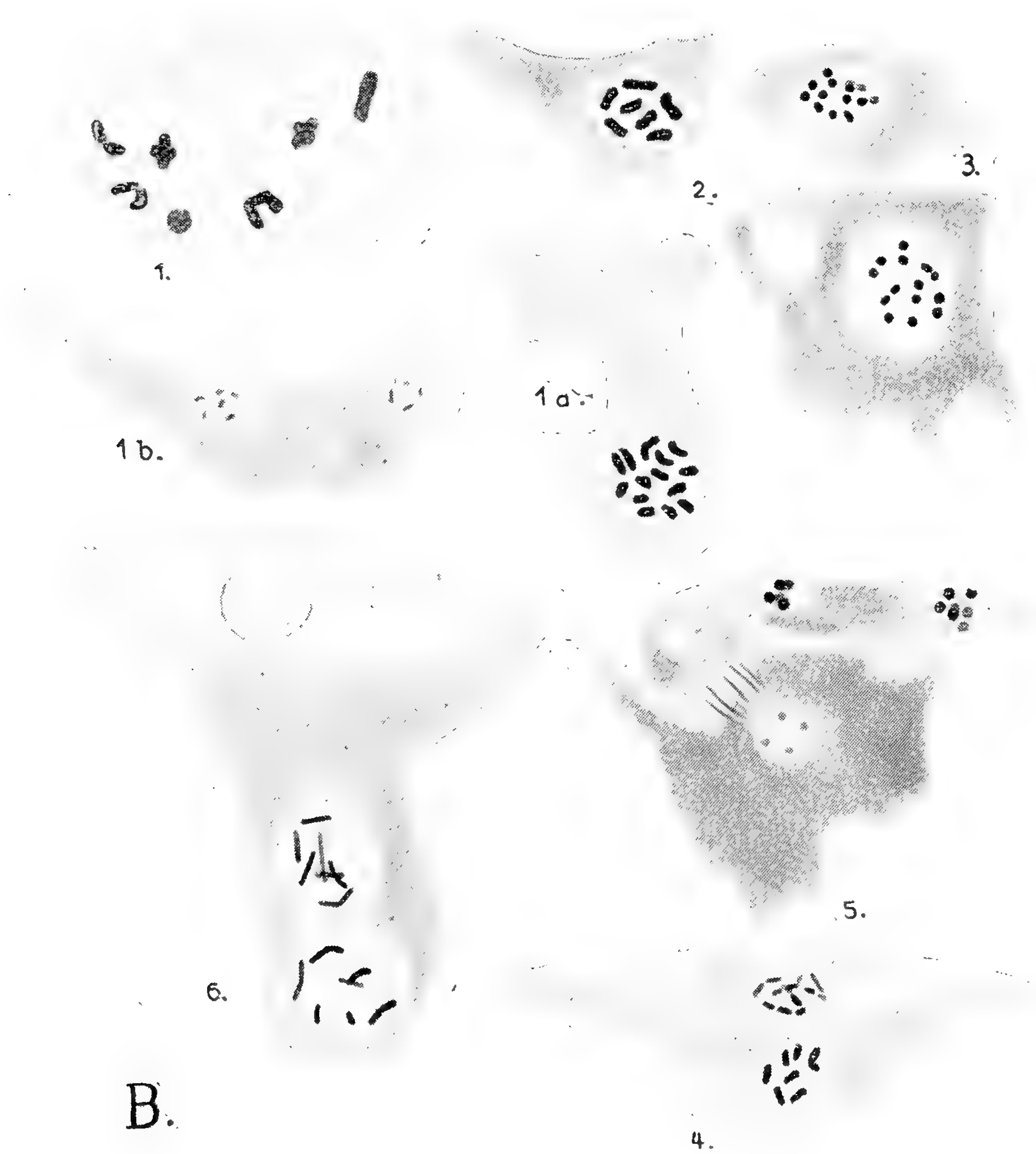


Fig. B.

Lecanium hesperidum, bisexual-parthenogenetic race. 1. diakinesis, haploid number of gemini. 2. metaphase of first maturation division. 3. telophase of first division, first polar body above and egg nucleus (oocyte II) below. 4. metaphase of second maturation division, chromosome parts reunited. 5. second telophase and division of first polar body. 6. fusion of egg nucleus with second polar nucleus, daughter nuclei of first polar nucleus at periphery. 7a. metaphase of first cleavage mitosis, diploid chromosome number reestablished. 7b. daughter nuclei of first polar nucleus at periphery of the same egg as 7a. (From Thomsen, 1927.)

The fact that a few times spermatozoa have been found in such eggs shows that they may be fertilized and then of course will develop normally.

The fate of unfertilized eggs has been elucidated in sectioning isolated virgin females. After the second meiotic division the egg nucleus sinks for a shorter or longer distance down in the egg, drawing some of the cytoplasm with it. Both the egg nucleus and the second polar nucleus are now almost achromatic, while in the daughter nuclei of the first polar nucleus some chromosomes may still be seen. The two first mentioned nuclei greatly increase in size and then the second polar nucleus also sinks down and approaches the egg nucleus. Presently thin thread-like chromosomes appear and gradually condense; at the same time the two nuclei meet and the indistinct nuclear membranes totally disappear (6). At this stage in some cases 7 chromosomes in each group are easily counted. The fusion of the two nuclei proceeds and soon the 14 chromosomes are seen lying in the same plane, constituting the metaphase of the first cleavage mitosis (7 a and 7 b).

Thus the diploid number of chromosomes is reestablished through the union of the second polar nucleus with the egg nucleus.

In several respects this fact may claim to be of some interest. Several textbooks of zoology indicate this process as occurring in parthenogenetic eggs, but in reality the case of *Lecanium hesperidum* is the first one where it has been shown to exist as a normal and simple method of restoring the diploid phase. In the much cited case of *Artemia salina* only Brauer found a similar fusion of the egg nucleus with the second polar nucleus, none of the later investigators having seen any such stages. Evidently in *Artemia* this represents an abnormal process producing abnormal (octoploid) embryos.

Before regarding sex-determination it is necessary to sav a few words about the cytology of the male. The male is diploid and heterogametic and in all essentials corresponds with the *Pseudococcus* male studied by Schrader. Half of the chromosomes may correspondingly be regarded as X-chromosomes, the other half as Y-chromosomes; they are separated in the second maturation division, thus producing two kinds of spermatozoa with 7 X-chromosomes or with 7 Y-chromosomes respectively.

The female being homogametic, its 14 chromosomes may conveniently be regarded as representing twice 7 X-chromosomes. As the reunion of the polar body with the egg nucleus only re-establishes this condition, it is obvious that the parthenoblast individual (the individual coming from an unfertilized egg) must be a female. On the other hand, males will only be able to develop from eggs fertilized by a 7 Y sperm, whereas eggs fertilized by a 7 X sperm will develop into females.

In fact the cytological findings correspond perfectly with our biological observations.

In other animals, too, the existence of different sexual races has been demonstrated *(Solenobia, Trichoniscus, Artemia, Daphnia, Rhabditis)* and in some of these cases the different races have a different geographical distribution, especially in *Artemia* and *Trichoniscus*. All individuals of *Trichoniscus provisorius* (a small isopod) from northern France as shown by Vandel are parthenogenetic and female producing, while in

s o u t h e r n France the parthenogenetic race is mixed with a gamogenetic one quite incapable of parthenogenetic development.

No doubt this question of geographical distribution is of great interest. It is a well known fact that in several species capable of parthenogenesis males occur in the South, but have not been met with in the North. Thus f. ex. males of *Apus cancriformis* and *A. productus* have only been met with in central and southern Europe, and somewhat similar cases are found in some Aphids.

Now as to *Lecanium hesperidum*, in northern Europe this species only occurs in greenhouses and has been introduced everywhere with plants, therefore it cannot give any information with regard to natural distribution of the races. The same is true of *L. hemisphaericum*, another common greenhouse species. Here, too, two distinct sexual races occur, one with obligatory parthenogenesis and another with facultative female-producing parthenogenesis. Thus it corresponds in every way with the races of *L. hesperidum*, only the diploid chromosome number is 16. The figure (fig. C, 1) shows the metaphase of the first maturation division.

I have recently taken up a study of free-living *Lecanium* species in the hope of throwing more light on this race question, but owing partly to the fact that I have to have material from various parts of Europe, my investigations proceed rather slowly. I acknowledge with sincere thanks the kindness of Dr. T h i e m of Naumburg and Prof. S i l v e s t r i of Portici in procuring material for me.

Lecanium coryli is generally distributed throughout Europe, though it mostly occurs only in small numbers owing to the high percentage of parasitized individuals. In this species males apparently have been found by all investigators. In my colonies from Italy and Germany they are almost as numerous as the females, and a few days before leaving Denmark I found them in a forest near Copenhagen also in rather large numbers. A cytological inspection of females from the different countries showed perfect agreement with the bisexual-parthenogenetic races of *hesperidum* and *hemisphaericum*, so that apparently in this species only one race exists. Though I must wait until next year for the results of the isolation and copulation experiments, there can hardly be any doubt of its faculty of parthenogenetic development. Therefore I venture to register this species as possessing facultative female-producing parthenogenesis. The diploid chromosome number is 18; fig. C, 2 shows the 9 gemini in the metaphase of the first maturation division; the correspondence with the bisexual-parthenogenetic races is obvious.

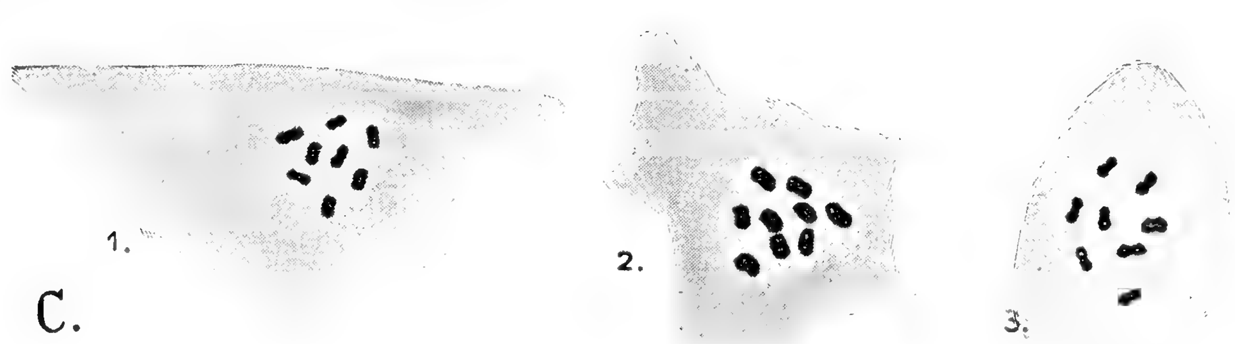


Fig. C.

Metaphases of first maturation divisions of three species of *Lecanium*. 1. *L. hemisphaericum*. 2. *L. coryli*. 3. *L. corni*. (Original).

In another common European species, *L. corni*, males are exceedingly rare. Dr. Thiem in Naumburg appears to be the only investigator who has found them in considerable numbers, and thanks to him I have been able to acquire a colony containing both sexes. Cytologically the females of this strain exactly parallel the females of *L. coryli;* i. e. evidently we have here another bisexual-parthenogenetic form (cf. fig. C, 3). In Denmark, as in most other places in Europe, males have never been seen. I therefore expected that our individuals of this species would belong to an obligatory parthenogenetic race corresponding to those of *L. hesperidum* and *L. hemisphaericum*. Nature, however, does not always fulfil our expectation, for it turned out that the Danish females of this species were identical cytologically with the Naumburg females; accordingly they must be referred to the same race. Even if it is not impossible that an obligatory parthenogenetic race might still exist in some place, this fact at least warns us against thinking that all *Lecanium* colonies consisting exclusively of females represent obligatory parthenogenetic races. They may just as well belong to a bisexual-parthenogenetic race. But why do males not always occur in such races? We have seen that males only develop from fertilized eggs; this means that if one or several virgin females of such a race are transferred in some way or other to a new environment without getting any males with them, they will reproduce parthenogenetically and give rise to a pure female colony in which males can never appear. It may be — and perhaps it is probable — that climatic or other environmental factors may influence the occurrence of the males, but we do not know anything about this point as yet. There can be no doubt that the primary cause of the rare and rather puzzling occurrence of the males in the different species of *Lecanium* must be sought in the peculiar kind of sex-determination in this genus.

Literature.

1. Hughes-Schrader, S.: Origin and differentiation of the male and female germ cells in the hermaphrodite of *Icerya purchasi* (Coccidae). Zeitschr. f. Zellforsch. u. mikr. Anat. 6, 1927.
2. Schrader, F.: A study of the chromosomes in three species of *Pseudococcus*. Arch. f. Zellforsch. 17, 1923.
3. —: The sex ratio and oogenesis of *Pseudococcus citri*. Zeitschr. f. ind. Abst.- u. Vererbungslehre 30, 1923.
4. Schrader, F. and Hughes-Schrader, S.: Haploidy in *Icerya purchasi*. Zeitschr. f. wiss. Zool. 128, 1926.
5. Thomsen, M.: Studien über die Parthenogenese bei einigen Cocciden und Aleurodiden. Zeitschrift f. Zellforsch. u. mikr. Anat. 5, 1927.
6. Winkler, H.: Verbreitung und Ursache der Parthenogenesis im Pflanzen- und Tierreiche. Jena 1920.

The Control of Root-eating Scarabaeid Grubs in Queensland Cane-Fields.

Edmund Jarvis, Bureau of Sugar Experiment Stations, Cairns, Queensland.

(With 11 text-figures.)

The world-wide damage caused by the larvae of various lamellicorn beetles to sugar-cane, cassava, pasture land, root crops, and miscellaneous economic trees and plants, has engaged the undivided attention of many scientists during the last thirty years or more.

The "White Grub" question in America, the notorious Cockchafer or "May Bug" in Europe, and the formidable "Grub Pest" of Australian cane-fields, constitute exceedingly complex problems which have for many years defied the efforts of entomologists, and at the present time, although partially solved, cockchafer beetles still continue to be responsible for tremendous financial losses.

It is interesting to note that the destructive species in each of these three examples are classed amongst the *Melolonthinae*, most of the grubs of which subfamily, in addition to their habit of ingesting soil and extracting from it organic matter, also devour living roots and the growing vegetable tissue of harder underground portions of plants.

While the majority of Queensland cane-beetles (including our most destructive) belong to the *Melolonthinae*; the subfamily *Rutelinae* is also represented in our cane-fields by two species, both of which, however, happen to be of minor importance.

In the present article it is my intention to deal with six of our northern scarabaeid beetles, all of which are common at times under cane-stools, and inflict damage of a more or less serious nature to the setts, roots, and subterranean basal portions of growing cane-sticks.

I. ON SIX NORTHERN SCARABAEID BEETLES.

1. Lepidoderma albohirtum Waterh.; Grey-back Cockchafer.

(Text-figs. 1—3, 10)

Undoubtedly, this beetle is our chief pest of sugar cane. While preeminently destructive in the North, it also ranges into our Southern cane-lands, effecting occasionally considerable injury around Bundaberg, Mackay, Proserpine, and other sugar-growing districts.

Life-cycle stages described:

Its obtusely ovate creamy yellow eggs are deposited in an earthen chamber formed in the soil by the female beetle, at a depth of from 12 to 18 inches or more. When just layd they measure about 4.25 by

2.85 mm, but when about to hatch assume a more rounded appearance, becoming fully 6 mm in diameter.

The grub, when fully grown (end of the third instar), is a little over 2 inches in length. In general colour it is creamy white, becoming pale bluish white and somewhat translucent at the beginning of each instar, the anal segment being suffused with brown, dark grey, or slaty blue, according to the colour of the soil ingested.

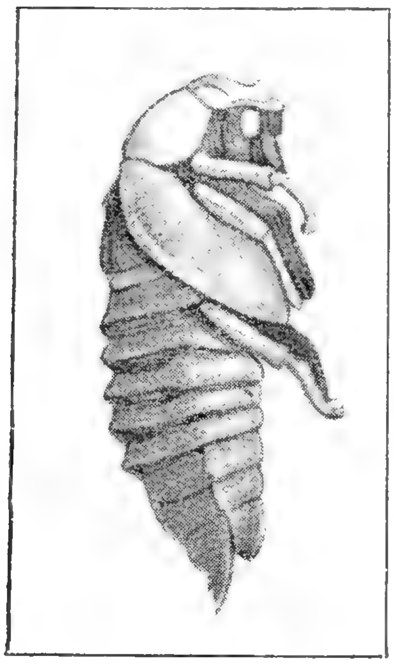


Fig. 1.

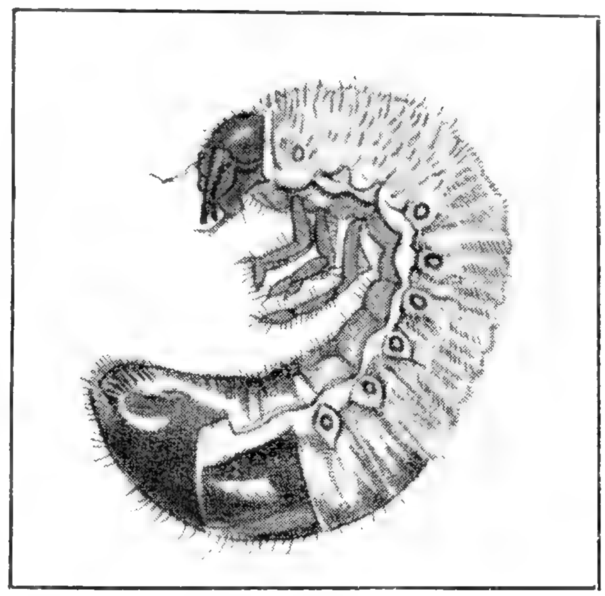


Fig. 2.

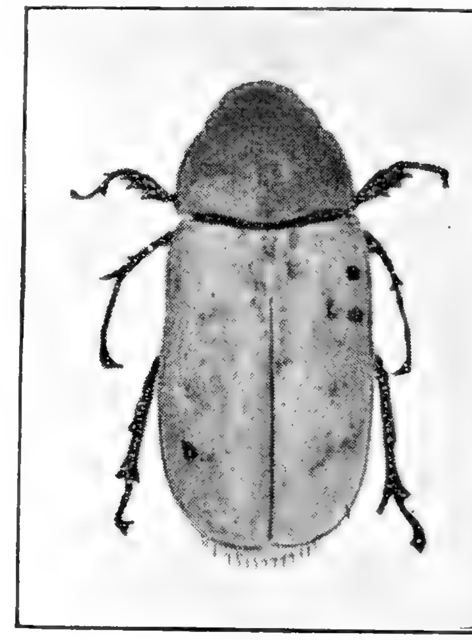


Fig. 3.

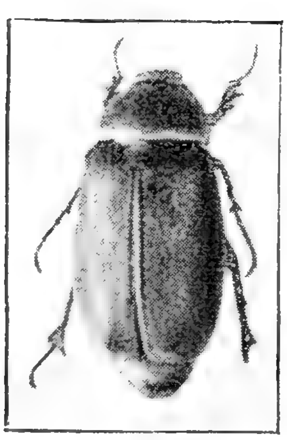


Fig. 4.

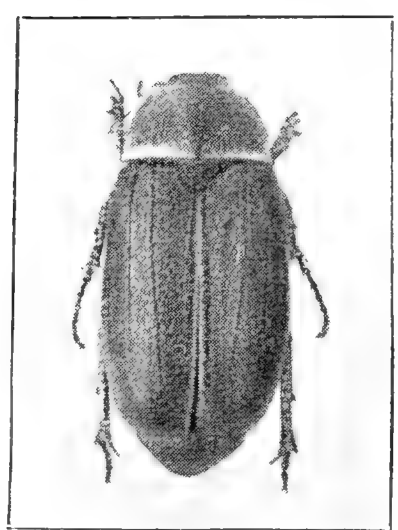


Fig. 5.

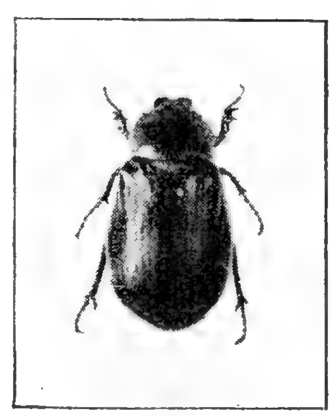


Fig. 6.

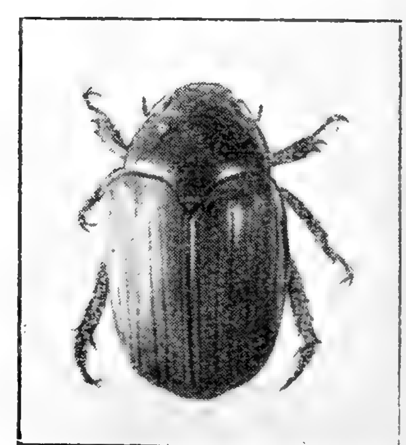


Fig. 7.

The grub of *L. albohirtum* resembles those of the species of the genus *Lepidiota* given below in general form and colouration, each of which, however, can be easily separated and identified by differences in the arrangement of the vestiture on the centro-ventral portion of the anal segment, which differences are well illustrated in the accompanying micro-photographs.

The pupa of the "Grey-back", which is about the largest of those of *Scarabaeidae* occurring in plough-furrows, measures 1½ inches long by nearly ¾ of an inch in width, and is furnished, as will be seen in the illustration, with two very noticeable horn-like processes on the cremaster. Its colour is dark yellowish red of variable degrees of intensity in different specimens.

The perfect insect is of the size and form shown in the photograph, the body being deep blackish brown, and more or less thickly covered (excepting on legs and centro-ventral area of abdominal segments) with numerous white, pointed scales.

Freshly emerged specimens are uniformly grey above, but after the lapse of a few days become more or less rubbed, the bare portions of the elytra, etc., appearing then as irregular dark blotches. A detailed description of the life-cycle stages of this cane-beetle, to which the reader may refer, if desired, has been published by the writer in the Queensland Agricultural Journal (Vol. XVI, pp. 46—50, 1921).

Unfortunately the life-cycle of this insect occupies only one year; a fact which doubtless accounts for its ability, during ravages of exceptional severity, to cause consternation among those growers whose selections chance to be situated in localities liable to such grub-infestation. The maximum amount of damage usually becomes apparent during the months of May and June, when affected stools turn yellow; indications which in severe cases are quickly followed by browning of the leaves and ultimate fall of the cane-sticks.

2. *Lepidiota frenchi* Blackb.; French's Cane-Beetle.

(Text-figs. 4, 8)

This Cockchafer appears on the wing during November or December, generally emerging from the ground a week or ten days after the first flight of Grey-backs.

Upon catching a specimen one notices a faint whitisch bloom overspreading the general body colour of dark reddish brown, which, if looked at with a pocket lens, is seen to be due to the presence of numberless tiny white circular scales. The outer edges of the pronotum of this insect are dark red, turned up slightly, and symetrically scalloped, the hind margin of same being densely bordered with these curious scales. The ventral surface of body, including the legs, is thickly clothed with white scales, which, on the thoracic plates, vary from circular to pear-shaped, and near the coxae are replaced by long silvery hairs. Its four life-cycle stages have been fully described by the present writer in Bulletin Nr. 5, Div. of Ent. of our Sugar Bureau, so need not be given here. Although in evidence each season, fortunately the grubs of *L. frenchi,* which are almost as large as those of *L. albohirtum,* do not injure cane-roots every year. These beetles are excessively abundant at times; damage to young shoots of plant and ratoon-cane being accomplished every second year during the months of September to December.

3. *Lepidiota caudata* Blackb.; Glossy Scrubchafer.

(Text-fig. 9)

Grubs of this beetle are common at times in cane-fields situated near scrub-land, and often responsible for serious injury. Growers constantly mistake them for larvae of *Lepidiota frenchi,* but the vestiture on the venter of the anal segment is darker in *L. caudata,* and the bristles forming the pear-shaped mass meet across and obscure the central path.

The perfect insect is deep purple or brownish red, of darker shade than in *frenchi;* the dorsal surface of its elytra being also more sparingly

and minutely punctulate than in the latter species, with the scales very much smaller.

This cane-beetle is one of the first to emerge, usually appearing on the wing during normal seasons early in September.

Like *frenchi*, *L. caudata* has a life-cycle of two years.

The beetles are said to feed on the foliage of Euphorbiaceous plants.

Fig. 8.

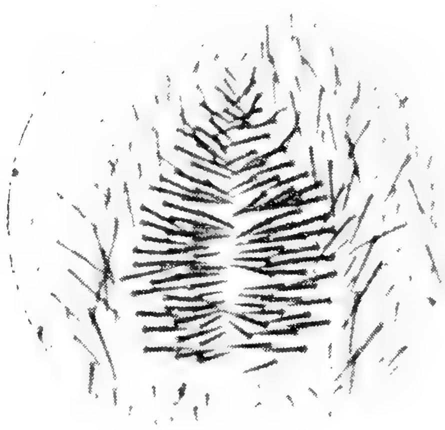
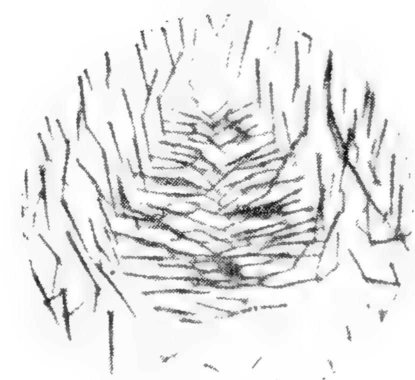


Fig. 9.



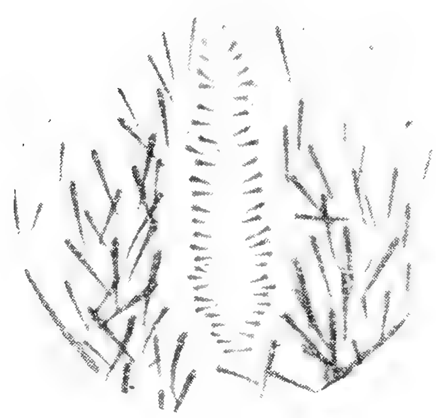


Fig. 10.

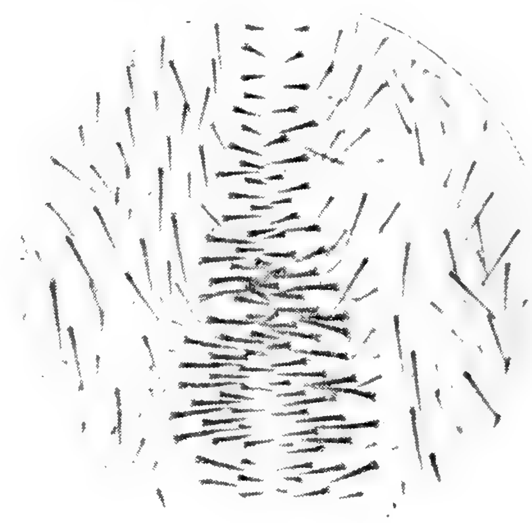


Fig. 11.

4. *Lepidiota consobrina* Gir.

(Text-figs. 5, 11.)

Closely resembles *L. frenchi* in general appearance and colouration. The beetles emerge, however, about three weeks earlier than *frenchi*, are of local occurrence, and much less numerous in forest country. It is easily distinguished from the latter by the following specific differences:

The Larva. — Setae on venter of anal segment in both species are arranged in the form of a pear-shaped figure, which in *consobrina* is elongated cephalad in two parallel rows of short bristles (see microphoto). Width of head 7.2 mm; in *frenchi* 5 mm.

The Beetle. — Average length $1\frac{1}{8}$ inches; *L. frenchi* 1 inch. Antennal joints 6 and 7 stouter in male than in female. The teeth on outer edge of front tibiae have the points more obtuse than in *frenchi*, and are not equidistant. Front tibial spur stouter and blunter. The ventral transverse bands on abdominal segments 1 to 4 narrower centrally and subventrally than in *frenchi*. In addition to the above differences the circular white scales on the elytra of this species are distinctly larger than those of *frenchi*.

Grubs of this Cockchafer are frequently found under cane-stools and in localities near scrub-land, where they often occur very plentifully and doubtless effect serious damage.

5. *Anoplognathus boisduvali* Boisd.; Christmas Beetle.

(Text-fig. 7.)

This beautiful beetle occasionally does serious damage in the Herbert River and other Northern districts, although around Cairns and Babinda it seldom proves troublesome except on localised areas in the immediate vicinity of low-lying or swampy ground supporting *Eucalyptus platyphylla* (Broad-leaved Gum-tree), which is the favourite food-plant of this insect.

Description. — Elytra pale creamy yellow, with faint green and pink iridescence, edges of suture green, about 20 rows of fine punctures on each elytron, half the number being straight and clouded in part with smoky brown, having the appearance of somewhat broken, parallel, dotted lines; outer edges of elytra bordered with golden brown. Head, pronotum, and scutellum metallic greenish gold, minutely punctulate. Pygidium bright green, edged with blue. Ventral area of body iridescent coppery green; thorax, legs, and anterior margins of abdominal segments more or less clothed with short white hairs; tibiae and tarsi purple. Length 25 mm (nearly 1 inch).

The fully grown grub is about the same size as that of *L. frenchi*, but its head is darker in colour and of lesser width.

The vestiture of the venter of the anal segment is quite different from that of the former species. Unlike larvae of *Lepidiota*, the grubs of *Anoplognathus* are able to crawl over level ground by lying extended on the ventral surface and steadying themselves with their legs, which project about a quarter of an inch on either side.

In the Burdekin district this insect is known commonly as the "Golden Beetle".

6. *Lepidiota rothei* Blackb.

(Text-fig. 6.)

This beetle is abundant every second year, flying at the same time as *Lepidiota frenchi*. Its grubs occur rather sparingly in cane-fields, where they subsist mainly on decaying vegetable matter, being often present in considerable numbers on trash which has been lying for a few months on the ground between cane-rows.

The perfect insect is dark shining reddish brown, covered on the elytra with innumerable fine punctures, each containing a single white pear-shaped scale. The ventral surface and legs are more or less densely scaled, excepting on tarsi and anterior margins of abdominal segments. Length 17.5 mm.

The anal path of the grub of *L. rothei* is bordered by two somewhat parallel rows of short bristles, which meet over the centre of the path, and are of similar colour to the surrounding vestiture.

II. HOW TO CONTROL GRUBS OF THE GREY-BACK COCKCHAFER BEETLE.

1. The Paradichlorobenzene treatment.

Initial experiments with this soil fumigant against our chief cane-beetle *(Lepidoderma albohirtum* Waterh.) was commenced by the Sugar Bureau during February to April, 1915; while, strangely enough, in the same year its use as an important insecticide was independently demonstrated in America, where Paradichlor was shown to be an excellent fumigant for combatting insects attacking stored products, etc. etc. At the very time when such conclusive results were being obtained in the United States, our laboratory experiments carried out by the writer in North Queensland against cane-grubs were also proving highly satisfactory.

It was not until the year 1924, however, that our Experiment Plots laid down on various cane-lands in the Cairns district served further to establish, beyond any possibility of doubt, the value of Paradichlorobenzene for destroying grubs of the Grey-back Cockchafer (Bull. Nr. 19. Div. of Ento. Bur. Sug. Expt. Stations. pp. 37—47, 1926).

Taking, for example, one of our Experiment Plots at Woree near Cairns, it should interest economic entomologists and cane-growers generally to learn that according to the figures supplied to the Bureau of Sugar Experiment Stations by the Colonial Sugar Refining Campany — who weighed and crushed the cane harvested from this plot (both on treated and check areas) at their Hambledon Plantation Mill — the plot treated with dry nodules of Paradichlorobenzene yielded cane at the rate of 27.208 tons per acre, whereas the grub-affected cane cut from the adjoining untreated check plot of similar size gave a yield of 14.032 tons per acre, representing the gain of an additional 13.428 tons of cane per acre as a direct result of such fumigation.

We must not overlook the fact that increased tonnage is not the sole benefit one derives from a control measure of this kind, since destruction of the grubs under plant-cane means also the development of healthy ratoons for the following season.

The above mentioned Experiment Plots were situated on friable soil of light red colour, which had been planted with variety D. 1135 about four months prior to being injected. The dose of Paradichlor used was ¼ oz., injected 4½ inches deep, and 12 inches apart on both sides of the cane-rows, 6 inches from stools.

2. How to apply Paradichlorobenzene.

The following methods have been tried at Meringa Experiment Station, viz. Machine application, injecting, and dropping by hand in an open furrow.

By the first method a man with a horse could fumigate about three acres of cane-land per day. The appliance used by us is a small corn planter adapted for such work by slightly altering the construction and making a few additions.

With such a machine uniform doses of the crystalline nodules can be buried close alongside rows of cane at regular depths and distances

apart; the soil above them being at the same time levelled and slightly consolidated by means of a special roller attachment. Both injecting the fumigant or dropping it by hand are cumbersome in comparison, although by the latter method it would be possible to treat small areas of young cane.

The various Experiment Plots laid down during 1922 to 1925 were fumigated with a special appliance designed by the writer for injecting dry fumigants at uniform depths and distances apart, as without some such aid at that period the doses would have had to be put in with a dibble or trowel. Not being intended for use on extensive areas of cane land, however, a man using the above appliance would not do much more than one quarter to one third of an acre per day of eight hours.

3. Quantity and cost per acre.

When treating ratoon crops from 3 to 4 feet high by machine application, a dose of 1¾ drachms (Apoth.) would need to be used on badly infested land, but in most cases ⅛ oz. will be found sufficient. For plant-cane one to two feet high, the dose should be about 1 drachm; while for still smaller cane 2 scr. (Apoth.) would prove effective. In each case these doses are to be administered fron 5 to 6 inches from the nearest cane-shoots, 15 to 18 inches apart, and about 4½ inches deep, on both sides of the rows.

Aproximately, the quantities required per acre work out as follows: —

Dose of 1 drachm. —	Placed 15 inches apart	113 lb.
	Placed 18 inches apart	98 lb.
Dose of 4½ scruples	Placed 15 inches apart	169 lb.
	Placed 18 inches apart	147 lb.

The price per acre, including labour, would depend largely, of course, upon the market price of Paradichlor. In Queensland, at the present time (May 1928), it would be about £6. 15. 00 for maximum doses — applied in exceptional cases to advanced ratoons — and £4. 10. 00 for the majority of crops requiring fumigation.

4. Paradichlorobenzene does not injure the cane.

During November of 1922 a field experiment in which 48 stools of young plant-cane about 14 inches high, growing on friable volcanic soil, were treated with ¼ and ½ oz. injections placed along one side of a row of D. 1135, and from 4 to 6 inches from the stools; an adjoining row of similar cane on each side of this treated row serving as check-plants.

Some of these injections were placed immediately opposite stools, and others diagonally in intermediate positions, all being 6 inches deep. When examined a few months later none of the treated stools were found materially injured by this fumigant, while some months later still, growth of both the treated and check rows was seen to be quite normal, not a single stool having been stunted in any way (see Bull. No. 18, Div. of Ent. pp. 25, 26).

Points to be remembered.

1. The vapour arising from Paradichlorobenzene is harmless to human beings and domestic animals. Being five times heavier than air it diffuses downwards through the soil from points of injection, per-

meating also in a lateral direction, and upwards through the surface soil during evaporation of moisture from the ground.

2. Paradichlor is non-poisonous, cleanly to handle, non-inflammable, and practically insoluble in water.
3. The correct time of year for administering this fumigant, modes of fumigation, cost per acre, etc., apply only to the Grey-back Cockchafer *(Lepidoderma albohirtum)*, which has a life-cycle of one year.
4. Do not use excessive doses; from 1½ to 3 scruples weight (Apoth.) is sufficient in most cases for plant-cane 1 to 2 feet high; and five scruples for older plant or ratoon crops.
5. Avoid placing the crystals closer than about five inches from the nearest shoots of very young plant cane.
6. Do not fumigate when the soil is very dry, or excessively wet.
7. Only one treatment is required each year, — to be given when possible during December or early in January, before commencement of the wet season.
8. Store this fumigant in tins or closely fitting wooden boxes when not required, to prevent waste from needless evaporation of the crystals.

5. The Bisulphide of Carbon treatment.

Past experience in Queensland has demonstrated the value of this soil fumigant for combatting cane-grubs.

Its great volatility, however, during ordinary temperatures renders it difficult at times to secure uniformity of evaporation under subterranean conditions, such troubles often arising from variations in soil porosity, due to gradual compression of the ground in places during growth and expansion of the basal portion and main roots of various trees or plants.

Field experiments carried out at Meringa have demonstrated that the eggs, larvae, pupae, and imagines of our Grey-back Cockchafer can be destroyed by fumigating such affected soil with Carbon Bisulphide.

The best time for using this fumigant is when the soil is firm, yet nicely moist, and with good porosity, while the surface is compacted owing to recent wet weather. If very dry or too porous, however, even large doses injected at such times may have little or no effect on soil-frequenting grubs or adults.

The following guide as to the best time for treating different classes of land will be serviceable to cane growers.

Highland volcanic soil, or coarse sandy loams: — From four to five days after a fall of 2 or 3 inches of rain.

Clay-loams, or fine sandy loams: — About six days on land that has been well worked and drained.

Sandy soils: — Two or three days after heavy rain.

Failure to secure good results from the use of Carbon Bisulphide is generally due to lack of essential knowledge on the part of the operator. When a farmer, who has neglected to fumigate at the right time, suddenly notices evidence of grub damage amongst his cane, he generally hastens to inject at once, without stopping to consider whether the soil be in a fit state for such fumigation.

The amount of Carbon Bisulphide required per acre would necessarily vary somewhat according to the age, etc., of the stool to be treated. One drum per acre (about 60 lbs.) has been recommended by some authorities

as being sufficient in most cases. For young plant- or ratoon-cane growing on light classes of soil doses of about 1 drachm, injected 3 to 4½ inches deep, 18 inches apart, and on both sides of rows planted 5 feet apart, should destroy 70 to 95 per cent. of the grubs. This would take about 1¼ drums (77 lbs.) of Carbon Bisulphide per acre — equal to about £2. 15. 00 for material.

A similar treatment would be suitable for older plant-cane or ratoon-crops, either on clay-loams or light soils, but in such cases it will often be found advisable to inject every 12 inches instead of 18 inches apart, which works out at about two drums per acre, equal to £4. 10. 00 for material.

Carbon Bisulphide should not be applied to very young cane just beginning to make roots, but treatment delayed until the stools are established, and the cane about two feet high.

6. Other Methods of Control.

The commonsense remedial measure of collecting the beetles and grubs is practised in some of the Northern sugar-growing districts, and has been found beneficial. As much as 1/6 per quart is sometimes paid for Grey-back Cockchafers, the usual price, however, varying from 6 d to 1/- per pound (about 272 specimens).

In the Herbert district 2/- per lb. is given for the beetles of *Anoplognathus boisduvali* Boisd.

The mode adopted for collecting Grey-back beetles is to shake or jar their feeding-trees during the early hours of morning, at which time these beetles are resting amongst the foliage in a semi-torpid or sleepy condition, and upon feeling any sudden vibration of the leaves or twigs usually release their hold, and falling to the ground are easily picked up or swept into sacks. Growers have been advised by us to plant or leave (when found growing naturally) clumps of feeding-trees, such as *Ficus pilosa* or *F. beniamini*, close to headlands at intervals of a few hundred feet apart, as these particular food-plants, which are much frequented by the beetles, would probably attract most of the specimens in the immediate vicinity, and also facilitate the collecting of same. Such trap-trees should be pruned at intervals, with a view to encouraging a low and spreading growth of leaves.

Several other forms, of an artifical and biological nature, for combating *Lepidoderma albohirtum* during its larval and imago conditions are being studied at Meringa Experiment Station.

Being an indigenous species, and able to breed unrestrainedly throughout vast tracts of uncultivated country, one cannot hope to eradicate this insect altogether. By practising the above-mentioned control measures, however, cane-growers are now in a position effectually to control, if desired, the ravages of this pest on areas devoted to the cultivation of cane.

The additional yield of sugar obtained from varieties such as "badila", which happen to be very susceptible to grub-attack — and owing to this fact are seldom planted on land liable to infestation —, would cover any cost incurred by fumigation of the stools.

The Future of Insect Taxonomy.

Dr. Walther Horn, Berlin-Dahlem, Germany.

Is there any actual reason for putting this address on our program? Are we standing at a turning point? When I received the honour of being asked to read this address, I remembered at once the words I heard while visiting the Prussian Ministry of Education scarcely two years ago: "You are coming to save a dying science". Before I enter upon the subject of my address a few words of explanation are necessary.

I. What is taxonomy? I interpret it as identical with systematics: taxonomic work is synonymous with systematic work. The aim of taxonomy is to bring order. What belongs to taxonomy? I refer you to the fine addresses by men like L. O. Howard, Gahan, Aldrich, Rohwer, Baker, Phillips, etc., in your country, to the fine discussion in London three years ago (Waterston, Imms, Jordan, and many other famous "ologists") and to the address by Gebien at Stettin last year. I fully understand that taxonomists have to survey 26 different "ologies" in 26 languages, 26 thousand entomological titles for the period up to 1863 and 260 thousand titles since 1864, as well as the greatest extent of general knowledge of mankind since Moses wrote his Pentateuch; and I am just a little afraid that the poor ganglia-cells of taxonomists are perhaps somewhat overcharged with all this knowledge.

II. The time of 30 minutes allowed for my address explains why the opinion expressed on many questions and based on personal experience can only be a sketchy one. I do not claim that my ideas must be regarded as absolutely correct: They may be quite wrong, but I hold them. Now for our theme.

1. What is the present position of entomo-taxonomy?

2. We shall give a short historical review; and

3. we have to face the question of the future of entomology.

As regards the present position of entomo-taxonomy, six principal questions arise:

A) In what consists our work?

B) What workers are there?

C) What are our tools?

D) What accommodation is available for carrying out the work?

E) What is our method of working?

F) Organization.

A) The Work.

The number of insect species may be estimated at from 5 to 10 millions. The concept of "species" is not yet uniformly defined. Casey, for instance, enumerated about 75 species of *Omus* from California, while I treat these as 3 only. Let us reckon for every species of insect one race or lower degree, and for larvae and pupae only 3 forms; that would involve 5 descriptions for each species, so that we should have from 25 to 50 million descriptions. 750,000 species may already have been described, which means about $^1/_{10}$ of the actually existing species. The study of their metamorphosis is a still more hopeless task.

Need we study all these forms? Would it not be sufficient, perhaps, if we were satisfied with a selection, as general zoologists are for their respective subjects? The answer is: In order to investigate the relationship of species we need to know all forms of the original plane of the moment as well as those of the reconstructed vertical past. Our knowledge of the latter will always remain very fragmentary. What would happen, if we did not avail ourselves of all the present-day material? We might agree that much of it is less needed for the moment; but is not our knowledge of such important groups as Ichneumonids, Braconids, Chalcids, Tachinids, etc., of the world simply shameful? It is even worse: the best descriptions become automatically out-of-date, and many descriptions have never been good. So we are facing a Sisyphus-task. To cope successfully with insect-taxonomy is an undertaking entirely different from the classification of birds or mammals.

B) The Workers.

We have to distinguish between professional taxonomists, amateurs, applied entomologists, and general zoologists occasionally or accidentally working in entomo-taxonomy. It is very difficult, if not impossible, to estimate the actual working hours of all these workers. Some may have only a few hours every month available for taxonomy, others ten hours a day. The greatest difficulty, however, is to decide what taxonomic work is really constructive with regard to classification, and what is merely for ornamental purposes so to speak. In spite of this difficulty we have to try to discover the difference, as the bulk of literature produced now-a-days in entomology no longer deals with classification as such. I hope you will understand what I mean by constructive and what by ornamental? Both forms of work are, of course, necessary for science, but research into the biology of a species is not always of importance for taxonomy, of which alone I am speaking. According to available records the number of amateurs of repute may be computed at 500, the number of applied entomologists who work in taxonomy at 250. The number of professional taxonomists is much smaller than is usually thought; I believe it to be hardly higher than 75 for the whole world. The same is probably true as regards general zoologists who occasionally work in entomo-taxonomy. So we arrive at a total of 900 to 1000 workers in entomo-taxonomy. The proportion between workers and insects, therefore, would be 1000 taxonomists as compared with 15 to 20 millions of insect-descriptions, or 1 worker for every 15 to 20 thousand descriptions; moreover, we must not forget in this connection that for a long time past two taxonomists dying have been replaced by only one beginner.

C) The Tools.

We have to distinguish between an absolute and a relative neglect of work in any one group of insects. I do not believe that there is any absolute neglect: Anybody who wishes to work now-a-days on insects as a non-specialist always finds plenty of material. A relative omission, however, will be the natural situation for every specialist, as it is theoretically impossible to find enough material. Much worse is the neglect in another direction, partly due to the taxonomists themselves, partly to lack of funds, such as

a) Catalogues, monographs, revisions of genera, etc.
b) Faunistic lists.
c) Bibliographical work.
d) Periodicals and cooperative publications.

a) Catalogues: — There is not a single complete catalogue of anyone order of insects. The relatively best one is perhaps the new Catalogue of Coleoptera, of which 94 parts are published; but many groups published in it have become out-of-date long ago, and others have not yet appeared at all; only two families are arranged according to modern classification, all the others merely in alphabetical order. The Catalogue of the Diptera of the World has never been finished, those of Hemiptera and Lepidoptera are just slowly starting, those of Hymenoptera, Odonata and Orthoptera are obsolete. We need not speak of the smaller orders at all. The number of recent monographs of families is equally small. I believe that hardly a dozen could be found altogether.

b) Exact Faunistic Lists: — Such lists have only been published for North America and some Palaeartic countries and even these are as yet by no means complete. As regards lists of other parts of the world it is better not to speak of them, as at most only a beginning has been made.

c) Bibliographical Work: — The entomological literature of the world up to 1863 is almost completely catalogued. From 1864 onward the entomological literature has been listed in various annual publications, of which by far the best are the Zoological Record and the Reviews of Applied Entomology, although their omissions are numerous, except in the last few years. It is a great pity that some of their volumes are out of print. We must add that in future it will be impossible to work only with annual records.

d) Periodicals and Cooperative Work: — It happens frequently that even the best manuscripts are rejected or only accepted in a mutilated form, particulary large revisions. Our funds for illustrations are totally inadequate.

D) Working Accommodation.

We have museums and other scientific institutes and societies. If we except the provincial and local museums, as well as the Congo Museum at Tervueren, all large museums are collecting the insects of the world. The most advanced museum is the British Museum, not only with regard to the size of the collections, but also from the technical standpoint of their arrangement. In addition it has the great merit of having published more first class catalogues and faunae than all the other museums together. In spite of this I believe that it is automatically falling short of the aim

to bring together a complete collection of the insects of the world, or even of the insects of the British Empire. The conditions in all the other museums are more or less hopeless. In most cases the number of insects coming in every year is always larger than the material of insects worked out at the same time. Thus the chaotic mass grows always larger. Indeed, no museum in the world would be large enough to accommodate the total insect population of the earth of any one year.

E) The Method of Working.

In Europe the education of entomologists as such in almost entirely autodidactic, even as regards those employed in museums. European universities hardly ever provide courses in entomo-taxonomy. We see again and again that beginners in Europe commence at the same starting-point as the previous generation. Only exceptionally does a museum of Continental Europe — I emphasize the world Continental — profit by the progress of other museums. Compare what Gahan said in his presidential address at Washington, 5 years ago, about the bad opportunities for taxonomists in the States. The most remarkable feature in present day specialization is that it shows up great duplication of work side by side with numerous lacunae. In most cases the choice of specialization is accidental, depending on the personal surroundings. Most specialists can no longer keep in touch with the work which is going on in neighboring groups. That is the reason why great taxonomic progress in one family remains very often without echo in other families. Every group is worked out in a different way. One bad taxonomist may do more harm than 10 good ones can repair. Sometimes the work of the best taxonomist is stultified by the bad work of others. I do not think that a similar state of affairs exists in other modern branches of Natural History, except Botany!

F) Organization.

The organization of entomology resembles the Sahara, being a sandy and stony desert, with some small Oases here and there. The largest normal Oasis is the cooperation of the British Museum with the Imperial Bureau of Entomology, and the largest abnormal one the connection between the U. S. National Museum and the U. S. Bureau of Entomology. We have certainly also other good examples, as for instance the Biologia Centrali-Americana of Godman & Salvin, the catalogues of the states of New York or Connecticut, etc. Certain commercial publications, such as Wytsman's "Genera Insectorum", the so-called "Tiere Deutschlands", the "Palaearktische Fliegen", have produced very peculiar results and are most dangerous for the following reasons:

1. The prices are often so horribly high that even museums and libraries can hardly afford them. Imagine that the "Palaearktische Fliegen" may ultimately cost \$ 700 to \$ 900, the "Genera Insectorum" already cost about \$ 1200.

2. It has been notorious for a long time that in Central Europe many entomologists work for pecuniary gain in the interests of commercial publishers, who frequently insist upon groups being dealt with of which good modern revisions already exist, sometimes even by the same author. The consequence is that much unnecessary work is published and that scien-

tific abilities of high value are not utilized for the most urgent work. Contract work has for a long time been known in Central Europe. Of all taxonomic questions only Nomenclature has been treated from the international standpoint.. Rules of Nomenclature are certainly a most valuable means of international understanding; but is it not characteristic of entomologists that international organization is only used in a branch which has the least possible to do with natural history research? It is true, Raphael Blanchard once called Nomenclature the Grammar of Science, but did he not mix up the words grammar and orthography? I could imagine that taxonomy might be called the grammar of entomology. Nomenclature is in fact only the handmaid of zoology, grammar being the "skeleton" of language.

Many museums continue spending much money for new insect material, for expeditions, etc., without thinking of the old material which is not yet worked out. The editing of some entomological periodicals offends even the most primitive ideas of economy in more than one way. How much time is wasted by neglecting method, and how crude in many museums and societies is the manner of treating correspondence! What one man, through energy and economy, can create, nobody has better shown than the late E. T. Cresson of Philadelphia.

Summary: — We arrive at this result that taxonomy is going to the bad. The fact that we all recognize this so late and so suddenly proves better than anything else that there is something wrong in the organization of entomology.

A Review of the past.

The most important questions are:

a) What has been the development of taxonomic entomology in the past?

b) Why has this course been a wrong one and who is responsible for all this?

On technical grounds we may distinguish 4 periods:

1. Period of Linnaeus. He, too, lived in a critical epoch, though his difficulties were other than ours of today. When still young he perceived that there was a trend towards chaos. Thus after the issue of 9 editions of "Systema Naturae" he settled the bill with a 10th one. The characteristic features of his working method were 1) that he recognized in a sharp way the differences between anatomy and taxonomy: taxonomy not being pure anatomy, but applied comparative anatomy, and 2) that he cleared the ground of a mountain of rubbish in not giving a single description without presenting the whole system. The result was grand. In 1758 he worked out, together with one other taxonomist, 65 genera and 1929 species. In 1767 he, together with 5 taxonomists, classified 77 genera and 2764 species. His entomo-bibliography of 1758 comprised 14 authors, that of 1767 already 29. It is of interest to note that in 1758 one entomological taxonomist diagnosed 950 species, in 1767 about 450.

2. The second period is the time up to the foundation of the great European entomological societies. The literature begins to be split up into single descriptions, but comprehensive work is still to the fore. I only

need mention Fabricius, Latreille, Olivier, Fischer von Waldheim, Thomas Say.

3. The third period is the middle third of the last century. The development of entomological societies facilitates the publications of endless short articles. The vastness of knowledge becomes too much for one human brain. The number of large revisions dwindles considerably. Cooperation and specialization are beginning. The registration of literature commences as a special field, not only in the form of annual reports, but also as comprehensive bibliographies. The catalogues develop into a kind of bibliographical lexica. In European universities the respect for taxonomy begins to disappear. Museums and private collectors clamour for tropical insects. The commerce in insects grows, and auction rooms flourish. Paris is the center of entomo-taxonomy in the world.

4. The fourth period starts from the end of the 19th century. Cooperative work is slowly undermined. The development of specialization leads to disintegration. Zoological museums increase their entomological collections rapidly, but many museums slowly go the way which the monasteries went during the middle ages. Museological knowledge is often only acquired after appointment. Entomological societies and periodicals spring up like mushrooms. Iconography is falling from the status of an art to that of a trade. Most museum officials and other scientists think only of themselves and their speciality. Specialization, bibliographical registration and similar work are being duplicated, while in other directions numerous lacunae are apparent. The mass of insect material becomes chaotic. Expensive expeditions often heap up material which remains in museums unused. Many museums know no longer what they possess, but are always hankering after more and more material. Private entomological collections are disappearing, going the same way which botanical and malacological collections have gone long ago. In England, I am glad to say, they seem still to flourish. Trade in insects becomes almost confined to Lepidoptera and some other insects that attract the eye. The artificial system in the shape of alphabetical or chronological lists or keys is returning to life. The idea begins to appear that every system is an artificial and transitory one.

The historical review reveals a stupendous backwardness of organization in taxonomy as compared with chemistry, physics, and other branches of Natural Science. In England alone the drawbacks are less noticeable.

1. The flourishing time of taxonomy is over. In the struggle with evolutionary theories and other branches of biology, taxonomy sinks to a kind of Cinderella. There are exceptions, which, however, only prove the rule.

2. The study of the concept of species, the highest duty of taxonomists, is absolutely neglected.

3. The real object of descriptions is only making relatively slow progress. Descriptions of a Dejean, Westwood, Redtenbacher, Schaum, Leconte are far better than many quite modern ones.

4. For a century the progress in museology has been starved in European countries. Many museums have only grown quantitatively during the last 100 years. The British Museum is the most brilliant exception.

5. The registration (bibliography and cataloguing) fails to keep pace with the influx of bricks and the accumulation of a mountain of rubbish.

6. Taxonomists seem to have renounced sanity in their methods of working.

Why has this course been a wrong one and who is responsible for all this?

a) Universities: In U. S. A. they are guiltless. In Europe they bear the full guilt: After having recognized that taxonomy is no longer suitable for modern teaching, they should have tried to create a substitute to take this branch over. They should have given way to the museums. But only a very few have done so, instead most European universities have done everything to knock taxonomy completely down.

b) Museums: We must acknowledge that museums were originally only intended for the housing of collections and were not concerned with the taxonomy of insects, with the organization of general entomological work, or even with the creation of entomologists. The social situation of many entomo-museologists became later on for many years so difficult that they forgot to make provision for the future, having too many other difficulties to content with, sufficient unto the day being the evil thereof. A certain fault is surely evident: the zoologists and museologists, particularly the directors, should have recognized earlier that taxonomic entomology was becoming chaotic. However, they were too prone to acquire collections of insects and failed to carry out their proper respective duties. From a technical standpoint they have scarcely ever recognized that objects of natural history have the opposite tendency to those of art: the latter become more and more valuable in time, the former almost worthless. The value of the type of *Omus dejeani* Reiche (1838) is nothing from the standpoint of natural history, having only an historical interest. In Europe too many museum entomologists are working as if they were private individuals. Entomological museums should cease to consider as their highest aim the bringing together of as many named or unnamed insects as possible. Much more necessary is the pulsation of entomological blood in entomological arteries.

c) Societies: The pecuniary situation of most entomological societies is such as to excuse them for not having done more during many past decades. On the other hand, what have they not created by their unselfishness and cheerful sacrifices! To save the future of taxonomy, however, is beyond their power.

d) Amateurs: In justice we must acknowledge that amateurs are still sacrificing much time and money for taxonomic entomology, but they can no longer cover the whole field of taxonomy. How critical the situation has become is illustrated by the fact that now-a-days many specialists possess only very restricted knowledge.

e) Applied entomologists: They have helped in more than one country, particularly in the classical country for applied entomology: U. S. A. The Imperial Bureau of Great Britain and the U. S. Bureau of Entomology have become the greatest benefactors of taxonomy. Altogether applied entomologists have certainly given more to taxonomists than they have got from them.

The question of the future.

A) The Work.

There are 3 possibilities:

1. We could renounce as overwhelming the study of the multitude of insect species, as has long been done by general zoologists. It seems reasonable that by skilful selection the needs of the day in applied entomology could be satisfied. But can a final system be built up if we refuse to do detail work in large branches? I refer you to the quotation from Linnaeus: "Cognitione specierum innititur omnis solida eruditio."

2. Could we diminish in some way the work by creating temporarily a larger working unit? I have published, in Entomological News XXXIX, 1928, pp. 172—178, a theoretical idea of this kind, proposing to abandon a final differentiation of species in all those cases where too little preliminary work has been done. We might attempt first to create blocks of species in order to facilitate a rough survey. The indirect outcome might be that amateurs, who often are no longer able to do work on a large group (as material, knowledge, and literature are too often missing) will yet be enabled to do the supplementary work of dividing all these small well defined species-groups. Such work would become cooperative for small circles: Every "primary" taxonomist who divides up larger groups would have to try to create around himself a small circle of helpers, so-called "secondary" taxonomists. Here a fine opportunity for assistance could be created for small entomological centers, societies, small museums or institutes. It is strange that my idea has been interpreted somewhere in the sense that museologists should no longer have the right to determine species.

3. Demolish the heap of ruins, but do not waste on it more time than it is worth. Quite recently I have raised the question (Entomol. Mitteil. XVII, 1928, pp. 87—90) as to whether it might not be possible to abolish all descriptions which cannot be interpreted, say within 14 years, even by the united efforts of all the entomologists of the world. That would approach a little Linnaeus's action in 1758. The question is whether it is possible to rouse the entomological world to make a general revision of all original descriptions with the one purpose, not of touching the good and a priori useful descriptions, but of uprooting the absolutely unusable ones. We should have to publish check lists of all names to be put on the "Index", so as to ask the whole entomological world to revise the descriptions up to a certain date, say 1940; otherwise the described, whether as species or varieties, would not come into consid- descriptions (and names) would be cancelled. The status of the insects eration. The plan is gigantic, but I believe it to be realizable if we show good-will.

The motto of the future is this: Do what you can to release taxonomy from the overburdening historical method. Make the time available for natural history research. To a large degree the solution of the conflict lies in that direction. It is benumbing, like the scholasticism of the middle ages, like anatomy and histology at the beginning of the present century. For example, in litteris names have from the standpoint of Natural History only the value of unpublished work, although they may be of some historical interest.

B) The Workers.

a) Professional taxonomists. — We must try to create more places in museums and other institutes, but the process will be a slow one.

b) Applied entomologists. — Following the example of the U. S. Bureau of Entomology and the Imperial Bureau, we should try to awaken in all countries the dormant taxonomic sense in applied entomologists.

c) Amateurs. — They will slowly disappear if we do not give them guidance and create opportunities of work for them, helping them by doing preparatory work of every kind, facilitating their work in every way, providing material, assisting them with bibliography and literature. If we do not do this, they might even become dangerous to some extent. On the other hand, we must not forget the first-class work which amateurs have done up to the present day. How much correctly named material have they not distributed throughout the world! Who will do this work in the future?

d) General zoologists. — Taxonomists could reawaken in general zoologists the zeal for taxonomic work by giving more frequent and better summaries of taxonomic publications, thus keeping the general zoologist informed as to the progress of taxonomy. Taxonomic work, especially in Europe, is often only digestible to specialists. It should be a question of honour for taxonomists to arouse the interest of general zoologists by propounding definite problems for investigation in the same way as the systematists in parasites help the student of tropical diseases. Something of that sort must be done in order to recreate the old respect for taxonomy. Taxonomists themselves should try a little harder to render the literature on taxonomy accessible to general zoologists. We have to construct a bridge leading from general zoology to entomo-taxonomy in both directions, just as the U. S. entomologists have constructed a bridge between taxonomy and applied entomology. But there is one point to which I should like to draw your special attention, although with a warning:

The question of exaggerated phylogenetic speculations. The controversy between the Darwin-Haeckel tree of life and the opposite hypothesis of fully isolated and only parallel lines of evolution of all species, will be cleared away, if ever, in the far future by new hypotheses. To-day all these ideas are only working hypotheses. It is only the idea of evolution that has to be respected. For the future of entomo-taxonomy we need much less phylogenetic speculations about families, tribes, and orders, than good descriptions of objective reciprocal relations between species and genera. All questions of the higher units are more of academic interest. To draw phylogenetic conclusions looks fine, but is not absolutely necessary. Systematic ideas transcribed into theoretical phylogenetical speculations have really little to do with true phylogeny. The greatest taxonomist whom the world has seen up to today was Charles Linnaeus: He created his system not from the phylogenetic standpoint, but from the analytic standpoint of relationships. That is why he created the picture of the "torn net". Only the smaller Epigenes have thought that taxonomy had to be bound up with phylogeny. Taxonomy is ordering, without saying anything about the way in which this order has come into being; if, on the other hand, you interpret Linnaeus's comparison of a "torn net" as a symbol of phylogeny, it would prove the polyphyletic evolution of species and genera. I know the biotic school and its inclination for laws,

but I warn you not to confound the two words "laws" and "rules". Laws don't allow of exceptions. Rules are based on exceptions.

C) The Tools.

We may perhaps be allowed to give some advice:

1. The first task should be to digest the material already accumulated in collections before we again and again spend further money on new material. By means of loans it is now-a-days possible to get more material than by expensive expeditions and purchases. In any case, the opinion that no material can ever be adequate should not permit us to replace a small evil by a larger one.

2. In most parts of the world the missing literature, the missing catalogues, and additional aids to bibliographical work are more urgently required than the insects themselves.

3. Preparation of catalogues.

a) Simple check lists, without the ballast of bibliography, should be compiled as the precursors of the bibliographical catalogues of the future.

b) Don't waste too much space in printing. The greatest waste comes from arranging the citations historically.

c) The two admirable reviews issued by the Imperial Bureau of Entomology should suffice as annual reports and be fully supplemented, but not duplicated or even triplicated.

d) The time has passed when we had a right to ask for catalogues arranged in such a way that even a beginner could understand them at once. It is no longer necessary that every amateur should make use of them for checking the species contained in his collection. It is not necessary to refer again and again to futile descriptions, "in litteris" names, etc., merely for the sake of purely historical exactness. One general citation followed by a supplementary list of the mere names of the species might be sufficient as regards many old works. For instance, we could reduce to a minimum of space most of the citations from Fabricius, Herbst, etc., excepting the original descriptions. The difficulty of the catalogue arrangement would, in my opinion, be solved, if the whole literature from 1758 on were listed in a similar way as in the annual Zoological Record, with this difference perhaps that the species names should be arranged one under the other in 2 or 3 columns so as to facilitate reference. By a combination of some such method we could save 50 % of the cost of printing. Scientists would soon learn to use such reformed catalogues. I draw your attention to the works of Chas. Leng and of Eichelbaum.

e) Bibliography: The most useful service which, in my opinion, could be rendered to taxonomy would be the compilation of the entire entomological literature for the period from 1864 to 1925. Taking as a basis the preliminary work done in my Institute and the "Index" up to 1863, I estimate the number of titles for this second period to be about 350,000. To print this number of titles would require 17 to 18 volumes of 1000 pages each, allowing 20,000 titles to each volume. The cost of printing such a volume in Europe would be \$ 10.— per copy, apart from the expenses connected with the manuscript. The possibility of solving this problem cannot be doubted, if a keen organizer with scientific and technical experience is in control. An expensive organization would be the surest way to defeat the achievement of the project. In my opinion the solution

of this problem is of the very greatest importance for the future of entomotaxonomy.

D) Working accommodation.

1) I do not believe that entomological societies will in the future be able to do much more within the limits of their own countries than to encourage the coming generation to bring out, by cooperation, faunistic and other work relating to their respective districts. Their first duty must be to create by national work an understanding for cooperative international work.

2) Museums: property entails duty. If museums continue to collect in the old style all the insects of the world (I do not speak of provincial and local museums), they will go more and more the way of the European monasteries of the middle ages. A certain danger for the future is surely lying dormant in the "large museums"! Museums should be organized to a certain extent like libraries. The "type-cult" has hatched out already over 100 technical terms, though we disagree even over the most important terms, co- and paratype. By means of photographs we might often facilitate a better knowledge of many types. As a solution I see only two possible ways:

a) The larger countries could still try to bring together a relatively complete collection of the insects of the world. The underlying idea is that all those zoological museums in which there are salaried curators and assistants will have to face a redistribution of the material, creating in this way a kind of reciprocal specialization. This would not preclude any museum from having a certain general representation of the remaining groups of insects. The larger the staff of a museum, the greater the number of groups with which it might deal. The best opportunities from this point of view would exist, of course, for the museums in Great Britain on account of the geographical extent of the British Empire. The greatest obstacle to this rationalization of museums is the absence of an altruistic outlook on the part of the administrators, and the misgivings as to the possibility of any museum carrying out such a program. Whether centralization would be the best is a worthless academic question. Any religion can be the best if it proves itself to be so through good works. If a clever taxonomist has a position in a central museum, centralization is very good; if an incompetent one has the position, centralization would be bad. What an entomo-museologist is able to accomplish single-handed has been shown in Italy by the giant of entomo-museology: Raphaelo Gestro.

b) In the case of smaller countries a plan of this kind is impracticable. They should restrict themselves, I think, to a general representative collection of insects and to the study of the insects of their own country. But besides that, even the smaller nations could create some special research centers, for instance, a center for one group of insects, for one biological or ecological complex such as cave-insects, water-insects, metamorphoses, special questions of bibliography, etc., in the same way as during the middle ages the construction of large cathedrals resulted in most cases in the production of an academy of architecture which lasted for decades or even for centuries. Danish entomologists have to a certain extent realised such ideas in studying the metamorphoses of insects.

c) In spite of all difficulties we should now try to do some preparatory work in an international sense. The American entomologists, for instance, might turn their special attention to mastering the insects of the new world. Much more difficult is the situation for the old world entomologists, as the world-wide British Empire shows very special interrelations, a certain internationalism based upon nationalism, questions which I refrain from entering upon here.

E) The Method of Working.

1. It is now really time to study the method of how entomo-taxonomy can accomplish its task. Who since Linnaeus has ventured to give a theoretical exposition of insect taxonomy? You find it mentioned in presidential addresses here and there, but that is not sufficient. Entomo-museology is not identical with entomological systematics. Entomo-museology is applied taxonomy. Entomo-museology could temporarily furnish a useful working arrangement not necessarily based on a so-called "natural" classification, for instance by the issue of card-indices or separate, arbitrary, chronological or alphabetical lists. Entomo-museology without card-indices is a poor bungling. Only by them the continuation of the entomo-museological knowledge of a museum can be guaranteed; without them every change of a curator or assistant would upset the work.

2. Revaluation of the pecuniary worth of insects. — Insects are not irreplaceable as are the objects of culture. In the ideal sense they have, with some exceptions, no higher value than mice, rats, and guinea-pigs. Museums should become more altruistic. The taxonomists, especially the museologists, should oftener dissect insects and preserve their single parts. Most insects show bilateral symmetry. One should remember oftener that the bilateral appendages allow museologists to keep one side in the collection and to lend the other out. Does a surgeon refuse to undertake an important operation because the bilateral symmetry would be disturbed? Another question is that of labelling. I know museums where sometimes no identification labels have been attached even to holotypes.

3. Correspondence. — I am acquainted with museums which answer only exceptionally. I know taxonomists who only write letters when they themselves want something. Correspondence is not a loss of time, but an economy of time. Museums should only buy collections or send out expeditions after every entomologist has got a typist and a preparator for technical work. Nothing is more expensive than to steal the time of scientists. All collections of insects become automatically too large. For the next 100 years potential types will too often go to waste because they are left undescribed.

4. Catalogues. — It should become common knowledge, especially for all directors of museums, that the best object for entomology is not the accumulation of insects, but their digestion. The aim of all museums and specialists should be to produce revisions and catalogues, taking as a pattern those of the British Museum.

5. The attitude of taxonomy towards the popularization of science, protection of nature, so-called monuments of nature, cult of "home, sweet home", etc., is in practice very often like that of a cat to towards a dog.

Summary:

What we need more than anything else is to recognize and to acknowledge that reformation is required both externally and internally.

I believe the 11th hour to be at hand. Progress can no longer be ensured by old-fashioned remedies. It would be fatal to take up an attitude of "laisser faire". The organization and administration of entomology is in a much worse state than entomological science. Support from individual patrons can no longer be looked for, nor can, in my opinion, help come from committees meeting once a year or every three years, sleeping and dreaming nicely in the meantime. Nor can help come from institutions where the work is done as a side-line. My personal conviction is that only a special "Entomological Institute for International Service" could still help. This should be an institute which excludes all questions of pure nomenclature, all practical questions of applied entomology, and, without the encumbrance of large collections, should work for international understanding and the national organization of the entomologists of the world. Only then the full benefit from international cooperation in taxonomic work will be realized, not only for taxonomy, but also for applied entomology. Such an institute need not cost a gigantic sum. It should save the entomological commonwealth much more than it costs.

In conclusion may I say this: we are standing on a sea-shore looking upon a chaos of waves, and the question now is: are these waves the catastrophic end of dissolution or are they the titanic struggle for rebirth? I hope, — I believe, that entomo-taxonomy will escape the fate of the Dinosaurs of the cretaceous age.

Discussion.

P. P. Calvert: My remarks are limted to the question: What phylogenetic principles should govern the application of taxonomic ranks?

I believe that it is not possible to make such an application. Considering the relatively great differences separating the so-called families of the Orthoptera (even in its narrowest sense) on the one hand, and the very much slighter differences between the so-called families of the calyptrate and acalyptrate Diptera on the other, it is extremely difficult to decide on how much difference is necessary to justify the separation of any group as a family from its nearest allied family. A similar illustration is provided by Dr. Tillyard's remarks at this Section's meeting yesterday afternoon, viz.: that it is very difficult to determine what should constitute the boundaries between the orders among the fossil insects. As long as there are such difficulties, no general agreement can be reached as to what taxonomic rank should be accorded to the various groups in the class of Insects as a whole. It involves the apparent impossibility of defining in the abstract what a genus, a family, or any higher taxonomic division is.

Fred. Muir: The increase in the taxonomic groups of organisms is not a modern tendency, but began to take place soon after the publication of Linné's great work, and is has been due mainly to our increase of knowledge and material available for study. The process is inevitable and shows a healthy growth. In carrying out this process moderation should always be exercised. As we have far from exhausted all the avenues in morphology, anatomy and biology available in our investigations, the process is bound to continue.

The work must be carried out quite independently of any consideration of the comprehension or capacity of the beginner or student. They must

learn their task the same as any other student of arts or sciences. With greater knowledge available for taxonomy the task will become easier instead of harder, in spite of the enormous increase of known species, etc.

In most groups of insects the divisions of species, genus, family and order, with their super- and sub-divisions, are sufficient, but in those groups where further divisions are necessary, there are already terms in existence which could, and should, be standardized.

For a long time to come it is advisable to keep taxonomy and phylogeny apart, while always working towards a "natural classification". We know so little about phylogeny, and much that we consider as knowledge will be discarded by future workers as ignorance. Phylogeny is the mature fruit of the tree of taxonomy, and it will be gradually revealed as our taxonomy proceeds towards maturity. To try to base taxonomy upon phylogeny is to erect a house before the foundations have been laid. Convergent and parallel development have played such important parts in evolution that it is often very difficult, if not impossible, to recognize them, and while the recognition of these are imperative for phylogeny, they are not so important for the immediate needs of taxonomy.

No rule to govern what is a primary or what is a secondary taxonomic character can be laid down, as they vary in the different groups. The desire to have "balanced" groups is quite immaterial, as one family may contain hundreds of genera and another only a single genus. Our phylogenetic trees are not all of similar growth, and an endeavour to prune them into similar shapes is bound to be a failure.

A. Ball: The question how to find a means of keeping species catalogs up to date is of importance to workers in all branches of Entomology. The taxonomist, however, can simply not do without a catalog of his group.

Now, the most carefully prepared catalog may contain some mistakes; it will always be out-of-date after a small number of years, and some groups have not yet been catalogued.

With the present cost of printing it is not possible to issue new catalogs as frequently as they are wanted. The scientific worker consequently has an enormous task in looking up reference books and publications before he can start real work. This purely clerical part of the work had better be done by someone whose time is not so valuable as that of the scientist.

The following points might be conducive to successful discussion:

Creaton of a new International Institute or Bureau that would have the task of keeping the bibliographical references in connection with new names up to date.*) In this case certain technical methods might be subject to improvement; for instance:

1. The keeping of card catalogs, to be published or not;

2. Printing on one side of paper, so that the references may be cut out and stuck on cards;

3. Improvement of system of information;

4. Use of a more appropriate system of classification in catalogs.

---

*) This agrees with Dr. Horn's suggestion.

The card system is theoretically the best manner of publishing a catalog. But the high cost of this method renders it prohibitive *(Concilium bibliographicum* cards of Zürich).

It might be suggested that the cards should not be published, but kept in a small number of copies at this International Institute, each series classified according to different principles: systematic, alphabetic, geographic, and so on. A specialist in a particular group could then have the cards referring to his studies copied at his expense. He could also ascertain whether a generic name he may intend to give is preoccupied or not.

If it should be judged necessary to publish a catalog and periodically to supplement it by new references, it might be more practical, if the supplement were printed on one side of paper only, so that the user might cut the pages into slips and stick them on cards himself.

The draw-backs of all reference books up to the present day have been:

1. They are always slow in publishing the references; and 2. they are incomplete.

Newly described species and new names are frequently omitted through the fact that the whole new literature is not always available to the compiler. This overlooking of part of the existing literature is most disastrous, causes great confusion, and multiplies synonyms. And yet the working up of the whole of the scientific literature is a tremendous burden on those who compile such a book as the Zoological Record.

There is a growing feeling among many systematists towards the idea that we shall some day have to introduce a rule by which a new name, in order to be validated, should have to be reported with full bibliographical reference to an International Bureau or Commission existing for that purpose.

To propose this sort of registration of new names would be premature. But when one comes to think of it, every author must wish that his work is taken notice of, and that the names given by him are recorded among those already existing. He ought therefore not to find it too great a trouble to inform this international commission that he has published such and such a paper, created such and such new names, or even to send a copy of his paper to the Bureau.

The burden of reference compilers would be considerably diminished, if it were rendered obligatory to register new names. I merely state this as an opinion which seems to be gaining ground rapidly.

Now, I have been speculating on the creation of such an Institute or Bureau. As far as I know, nothing definite has been done yet, and the ways of getting the necessary funds for establishing this Bureau and for keeping it going are still to be found. But as it is, something might perhaps already be done now in the direction of having the minds of the scientific world prepared for the future.

G. J. Ferris: The modern tendeney toward an increase of the taxonomic groups and toward the raising of rank of these groups is in part probably due to inadequate biological training on the part of systematists in general and a consequent failure to view their work as an expression of biological principles.

But it is also in part an expression of increased knowledge. We cannot return to "Linnean genera" and still express the greater body of fact that we now have available.

Any classificatory system that we may evolve must be a compromise between the demands of abstract theory and the necessities of concrete practice. At the very best such a system can be nothing more than a skeleton, an abstract, a sketch, of the arrangement of the entire series of groups that could be recognized, that actual number being almost infinite; for any two, and three, any four or any other number of species that may be taken will form a group more closely related to each other than to the members of any other group.

A system which will lend itself at once to the abstract theory of the specialist and to the demands of the non-specialist can be developed by an expansion of the existing generally recognized system, involving the recognition and formal naming of super- and subcategories of each standard group in the following way:

Phylum, subphylum; superclass, class, subclass; superorder, order, suborder; superfamily, family, subfamily; supertribe, tribe, subtribe; supergenus, genus, subgenus; species group (for which some term other than superspecies should be devised), species, subspecies. No formal scientific names requiring nomenclatorial recognition should be given to such things as seasonal forms, color varieties, and the like or to any forms which are derived from the same parentage.

Such a system will allow of an adequate series of groups to express most of the needs of the specialist. By condensing this and using only the central categories (family, genus, etc.), a system suitable for the non-specialist will result.

The proper formation of names for these categories and the designation of type forms as is now done with genus and family should be specified as a part of a nomenclatorial system.

There can be but one principle in the recognition of such categories — they shall express groups of apparently different phylogenetic ranks. Groups which appear to be derivable from a common group should be placed as coordinate under that higher group. A group which is demonstrably an off-shoot from another group should be placed as subordinate to the group from which it is derivable.

The essence of any such arrangement is g r o u p i n g in accord with general biological principles. Any category, from the genus up, to be of biological value must express an actual group. On this basis the tendency toward monotypic genera should be resisted.

F. S i l v e s t r i : I think that the tendency towards infinite increase in the taxonomic groups of organisms is not justifiable, inasmuch as it is more embarrassing than useful. If we admit species, genus, family, order and class, we can get a larger complex by the addition of the prefix s u b to the rank named, so that we have plenty of designations for the various groups of individuals, species, genera, etc., and can be satisfied. Though specialists more and more study small groups and more and more discover numerous entities, it is not necessary to give a name to each of such divisions; he will explain everything in his publication, but should refrain from complicating the nomenclature by the introduction of many unnecessary names. Generally the specialist has a narrow horizon and, moving

in it alone, believes to be in a great world and likes to give a name to every speck of dust, to every pebble and then, in his mind, the group he is studying swells so much in importance that he considers it to be an Order or Class, while it really is only a family, and so forth. What do we gain by raising to the rank of families the subfamilies of *Chalcididae* and *Coccidae*, and to the rank of Superfamilies or Suborders the respective Families of *Chalcididae* and *Coccidae*? Nothing at all.

As regards the future of insect taxonomy, I should like to make the following remarks: In order to achieve the necessary progress in entomology it is first of all required that in all countries there are Institutes or at least a Museum with a sufficient staff of systematic specialists and technical assistents for collecting, preparing, preserving and studying the insects of that particular country. As long as there are so few Museums in the world, provided moreover with a very limited staff, entomology will remain in a state of childhood, notwithstanding the efforts of the actual few entomologists. Local Museums well equipped for collecting and studying the fauna of their part of the world are much needed. In saying this, I do not mean that general Museums are not to be encouraged, but I affirm that they are not so useful to science as somebody might maintain, because a general Museum, rich as it may be, will never be able to unite in a tremendous collection all the insects which are being discovered little by little in all parts of the globe. It is certainly very important to exhibit material for the education of the general public; but beyond that, rich local (national, regional) collections are wanted for scientific research, and in proportion to the financial possibilities and the availability of competent men, rich collections from all countries of one or the other group or of many groups should be amassed for specialists in systematics to study. The local Museum when scientifically organized should 1) be the repository of the types of all the species living in that area (national or regional) of which it has particular charge, and 2) send in exchange cotypes or paratypes and duplicates to specialists or Museums requiring them. As unfortunately we cannot hope to get in the near future such a general organisation of Museums throughout the world, and as large and very interesting countries will remain, for a long time to come, without a Museum, or without a truly scientific Museum, I think that in this transitory period the Congress should recommend that richer Museums should plan methodic exploration of extraregional countries, and that the material collected should be liberally exchanged with other Museums or with specialists and not, as is often the case, be left hoarded unutilized or even destroyed.

A. Dampf: Taxonomy, as every science, has a sole purpose: to find the truth. This means in our special case to find out the true phylogenetic relationship of all existing and extinct forms, be this task simple or complex. The second and more practical purpose of taxonomy, in pre-Darwinian time the chief one, is to bring order into the chaos of organic beings.

It seems to me that the problem put on the program under the heading "Taxonomy and Phylogenetic groups" has not so much bearing on the real scientific taxonomy as on the artificial constructions prepared by workers more enthusiastic than profound, and sometimes by men who had lost all perspective. I believe, for instance, that the complicated classification of Strepsiptera proposed by Pierce, or that of the Aphaniptera

or fleas proposed by A. C. Oudemans, do not express the true phylogenetic relations, which are simpler. At the same time, I am convinced that the present classification of Lepidoptera is a very unsatisfactory one and that it does not correspond to the infinitely more complicated phylogenetic network which this order presents to the more thorough student. To safeguard the working of the taxonomists — surely very important and basic for all biological sciences and a science itself — I would warn against any reglementation, which probably would curtail free research. The taxonomist who has the difficult task to find out in what relations the innumerable groups of living things stand to one another, should not be embarrassed by any prescriptions.

Those whose duty and profession it is to transmit the scientific achievements of Taxonomy to the students and to the younger generation in general, must find the golden midway between the conservative and the progressive mode of view and must possess the necessary tact to distinguish between permanent achievements and hypothetical ones. As a teacher must always abstract, there would be no difficulty for him to make Taxonomy comprehensible to the general student, but the taxonomist himself cannot take into account the wishes of beginners.

The whole problem depends on — to put the finger on the point — how we look at the species question. The taxonomist who understands that there are more than individuals in living nature and who realizes that the genetic forces which form the individual have more reality than the phaenotype, will be on the right way. Prof. Kusnezov, of Leningrad, has published some years ago a very interesting paper on taxonomic units and their relation to morphology, in which he calls attention to the fact that there can be no doubt about the existence of groups of individuals which forms units, but that every unit has its special value, which depends upon its history; that Taxonomy is working with incomparable units and that our systems can never express the reality.

This would mean that the fortunately inaccessible goal of Taxonomy is incomprehensible complexity, but this would also mean that the only way to get the necessary order is to begin with the lowest taxonomic units and to follow their distribution and development in every faunal region and not, as it is done so often, to limit the work to the forms "north of Mexico" or to the Palaearctic species or to the Australian ones. Entomology is international and Taxonomy has to be it also.

The Relation of Taxonomy to other branches of Entomology.

Professor Filippo Silvestri, Portici, Italy.

The species of insects described until today number about 650,000. This figure must for all the existing species be multiplied by 5 at the very least. We have therefore to deal with a tremendous multitude of different insects. But however high the actual figure may be, we are convinced that there is no escape from the necessity of giving a name to and publishing a description of every one of the species, because no branch of entomology can progress without having fixed the distinguishing characters of the species we are working with. We maintain that taxonomy is for entomology what the fundaments are for every building. We may look upon entomology as a human monument which can be raised to a very great height and which may stand out as a most imposing structure. But the condition is that taxonomy, which gives us the key by which to identify the insects, be developed thoroughly in such a manner that the recognition characters of each species are clearly set out. If that is not done, we shall have, instead of an impressive and perfectly ordered edifice, a useless accumulation of facts, a veritable tower of Babel, resulting in the absence of progress and applicability. We therefore maintain that taxonomy should be developed to the utmost and be technically as exact as possible. But we cannot pretend that taxonomy is already perfect, namely, that each species is being described with every kind of detail and illustrated by drawings, for this would require a great deal of time. Even if the number of specialists were much larger than at present, the naming of the species would not be rapid enough for the workers in other branches of entomology, especially for workers in applied entomology, the development of which we should much like to see accelerated. We must therefore ask the taxonomists that the descriptions be exact and, though short perhaps, be sufficient for distinguishing one species from the other, and we add that the first duty of taxonomy is and should be the discrimination of all the existing species by means of descriptions and names. After this first step, and perhaps associated with it already from the very beginning, will follow the second step: of studying thoroughly a family, or a group of another rank, and of extending research to morphology, phylogeny, distribution, and so on. In view of the tremendous number of species, I consider it of the highest importance that there should be many pure taxonomists, particularly in museums and other institutes where collections of insects are being kept, this category of entomologist having to prepare the way for other branches of entomology, in which likewise many workers are required. There is no doubt, we all agree that profound studies are necessary to acquire a truly scientific knowledge of a group of individuals

we call a species; studies which, beginning with the external characters, must extend to the internal morphology, cytology and embryology. This very complex research, however, is not required in the case of every species, but we consider it highly desirable that it is carried out at least with one species in each family or lower group, though we cannot hope to see it accomplished in a short time. We must emphasize the utility of it, and we urge students to devote themselves to this kind of research.

But to return to our point. We require at present a taxonomy which is able to give us the means of distinguishing with sufficient exactness the insect A from the insect B, for we are in urgent need of knowing the biological and other qualities of the insects from the point of view of pure taxonomy as well as from that of applied entomology. In my opinion, pure taxonomy is an absolute necessity and therefore must be very much encouraged. But I hasten to point out that taxonomy must not be considered the end of all entomology: taxonomy in all its aspects is most useful to science, but we want knowledge useful to humanity also, and we emphatically claim for entomology that it can procure the maximum of delight for the mind and the maximum of practical application for humanity. This high aspiration of entomology involves the study of biology: when we have the elements for recognizing a species, we study the life history from the egg to the adult, and the relations of the insects to the other organisms and to the inorganic conditions of its surroundings. For such research taxonomy is fundamental. But taxonomy is static, and as we aspire above all to a dynamic entomology, we must direct our efforts to develop also those branches which accord humanity the greatest benefit. It is certainly very interesting to be able to identify all the species of insects, to know their structure from the germ-cell to the complete insect and to ascertain the function of each organ; but in order to understand the part which insects play in nature, we must also intensely study the relations of insects to their organic and inorganic environment. Entomology can be proud of its contributions to science, particularly to applied science, during the last forty years. We need only recall the biological studies in insect parasites, social and inquiline species, metamorphosis, polyembryology, and so on. What great service has not entomology rendered to humanity by its researches on blood-sucking insects, insects injurious to plants, and insects controlling pests! The imposing body of all such research, from which all branches of pure and applied science have unquestionably received a great impetus, has only been possible to be build up, because there was the secure fundament of taxonomy, from which research aiming at a complete biology could start. In all such research taxonomy has been the guiding thread of Ariadne, without which no result of importance could have been accomplished. But we must add that no useful conclusion would have been arrived at, if research had not embraced ecology and bionomy. Therefore we must insist that all branches of entomology be cultivated, placing taxonomy at the base and biology at the top. In order to reach this summit the entomologists of all countries should join efforts for the benefit of all nations.

As an example, I may mention the ravages due to locusts in several countries. Although the subject has been carefully studied in some countries, little or nothing has been done in others. If we had a complete knowledge of the biology of the locusts in all countries, it would not only mean a

great scientific enrichment of entomology, but many facts ascertained in one country would be of the greatest importance for other countries. Until we have such complete knowledge of an insect, from taxonomy to biology, our statements and our conclusions will have only a limited value or none at all, or, what is worse, may be altogether erroneous, because based on fragmentary evidence which touches only one side of the problem. What I have said about the locusts applies to many other insects. That is known to all of you and I need not dilate on it. But what I should like to emphasize at this International Congress of Entomology is the fact that all branches of our science are of importance and require greater support in all countries. I am sure that Entomology, using taxonomy as the fundament on which to build an edifice of Biology, will arrive at extremely interesting results in pure and applied science and thus become more and more worthy of esteem and receive the support of the people and of the governments.

Biological Control of a Sugar-cane Aphid by transferring its Native Parasite from the Old to the Young Fields.

Dr. E. H. Hazelhoff, Java.

(With 3 text-figures.)

In cane-fields on Java (the third cane-sugar producing country of the world) there occurs a woolly Aphid, *Oregma lanigera* Zehnt., which is probably the most severe pest of this crop after the moth-borers *Diatraea* and *Scirpophaga*. Several cane-estates spend a sum of two or even four thousand dollars annually in combating this pest; lime-water and oil-emulsions are the insecticides most commonly in use. Since native labour is cheap and large spraying machinery cannot possibly be moved about in the extensive and densely planted cane-fields, all chemicals are applied by hand or by portable spraying apparatus. A serious drawback of the hitherto known methods of chemical control is that the results are often very disappointing; in some cases, it is true, good results are obtained, but mostly a renewed outbreak of the pest occurs and application of insecticides has to be repeated several times in the same field. Some of the cane-growers maintain that, in general, insecticidal control does more harm than good, since it aids the lice in spreading from one spot to another; they believe that the pest when left undisturbed never spreads to such an extent as when chemical control has been tried. As to the infestation with lice, there is a very marked difference between different fields which are under very much the same conditions in every respect; even in different parts of the same field the infestation often differs considerably. The great majority of the fields remain practically free; severely infested fields, however, can suffer a very great loss in yield, in extreme cases the crop being reduced to about a half of the normal yield. It was considered that an investigation of the true cause of this remarkable difference possibly could give valuable indications as to the best methods of combating this pest.

In Java triennial rotation of crops is practised; each year one third of the fields of a definite area is planted with cane, and during the next two years these fields are left to the natives for the cultivation of rice and other less important crops. Sugar-cane is planted from April till September and harvested next year from May till November; no ratoons are taken.

Infestation of the newly planted fields generally begins in the months of June, July or August; in September and October the infestation rapidly increase in some fields only, and in October or November a maximum is reached. In January and February a rapid decrease of the pest is observed, and from March onward Oregma is extremely scarce. This

very marked decrease of the pest was considered formerly to be due to the change from dry to wet monsoon, which in Java takes place about November; casual observations in December 1926 and January 1927 led me, however, to the supposition that the native parasite *Encarsia flavoscutellum* Zehnt. *(Chalcididae)*, which was then very numerous in nearly all *Oregma* colonies, might play a very important part in it. This parasite turned out to be so extremely important that it seemed reasonable to suppose that its presence or absence in the young fields might decide whether or not *Oregma* was held in check.

In order to test this supposition I determined the percentage of parasitism in a number of *Oregma* colonies, and at the same time observed the increase or decrease in size of these colonies, expressed in terms of the number of cane stalks infested. The percentage of parasitism is determined in the following way: a sample of about two or three hundred lice is gathered in a glass tube with 2 or 3 cc. of a saturated solution of chloral hydrate in benzol *); after a few hours the lice have become quite transparent, and the percentage of parasitism can be determined within 1 or 2 minutes by examining 100 lice under the binocular microscope. Strict precautions were taken to get samples representing the true average of the whole colony; the lice of one sample must be gathered from 10 or 20 different leaves, regularly spread over the whole colony. The importance of accurate sampling is easily recognized when one considers that the lice of the top leaves may be parasitised for about 5 % only, when the percentage of parasitism on the lower, older, leaves of the same plant is over 50%.

From June 1926 till April 1927 several hundreds of colonies spread over the whole island of Java were investigated in close cooperation with 90 out of the 180 plantation managers, the samples being taken by the European plantation assistants and sent to the Experiment Station at Pasoeroean, where the percentage of parasitism was determined. In this way a total number of more than 4500 samples were analysed, the following number of samples being sent in the successive months:

Table I.

Year	1927							1928				
Month	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Febr.	March	Apr.	Total
Number of samples	8	73	355	872	944	825	724	446	110	16	27	4400

We may assume that these numbers at the same time are fairly well proportional to the increase and decrease of the pest in the successive months as discussed above.

It was very remarkable that most of the samples taken in the months of June, July, August and September were very poor in *Encarsia;* in the months of October and November *Encarsia* became more and more abundant, and from December onward the majority of all samples were rich in *Encarsia.* The percentage of all samples showing more than half of the lice parasitized increased from 0.0% in June to 24.7% in November

*) After Dr. P. J. van Breemen in Archief voor de Suikerindustrie in Ned.-Ind. 1926, Vol. II, p. 408.

and to 82.4% in February (further details in fig. 1; striped columns indicate that in the month referred to less than 70 samples were received).

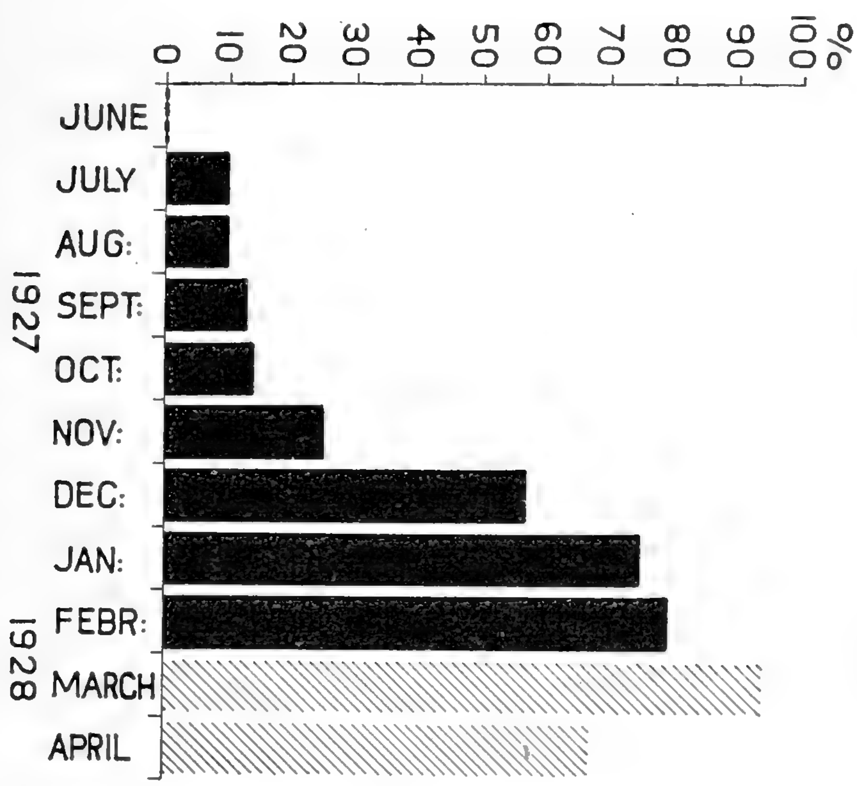


Fig. 1.

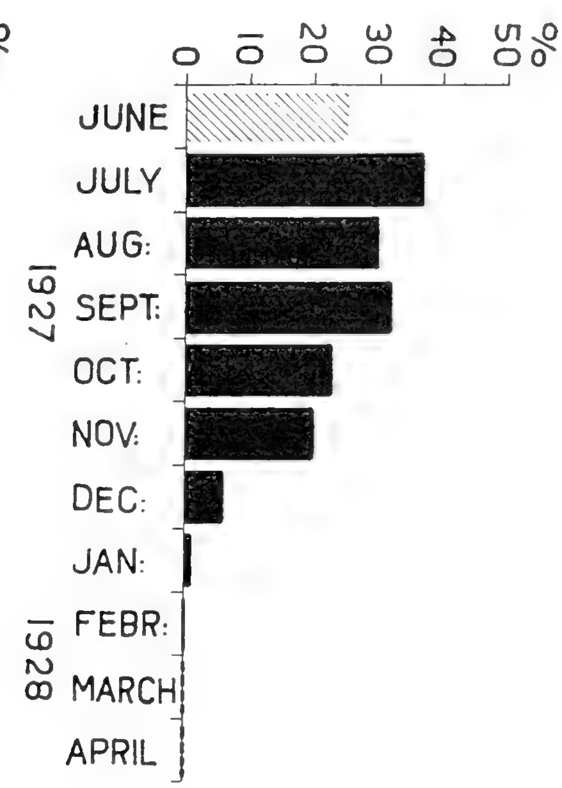


Fig. 2.

Fig. 1. — Percentage of all samples showing more than half of the lice parasitized by *Encarsia.*

Fig. 2. — Percentage of all samples showing no parasitism by *Encarsia* (0 %).

On the other hand, samples with no parasites at all, which were rather numerous from June till October, became more and more scarce in the next months, and from December onwards hardly ever occurred (fig. 2).

In the months of May, June and July 1927 a number of samples taken from the old fields were also investigated. Of 114 samples 31% showed more than 50% parasitism, and 68% more than 30%. Since in the same months *Encarsia* was very scarce in the young fields, the conclusion must be drawn that this parasite generally fails in timely following *Oregma* to the young fields; apparently the flying capacity of *Encarsia* is not great enough to warrant timely infestation of all young lice colonies in the newly planted fields. Moreover, several field-observations made during the months of July till November 1927 indicate that in those fields where *Encarsia* happened to be present in time, the pest was completely held in check. On the other hand, in those fields where the pest was spreading with alarming rapidity *Encarsia* always turned out to be absent or at least very scarce.

We may conclude that the native parasite *Encarsia flavoscutellum* is of much use by keeping the pest in check in most cane-fields, a severe outbreak of the pest only occurring in those fields where *Encarsia* failed to become established in time. It is easily understood that the host has a much better chance than the parasite to become established in a young field, since the former only wants to get into a young cane field, whilst the latter is over and above that entirely dependent on the presence of its host. — Winged individuals of *Oregma* are never parasitized.

By taking several samples of the same lice-colony in intervals of two or three weeks I was able to follow the successive stages of the same

colony. As is to be expected from mathematical considerations, the percentage of parasitism at first increases slowly and later on more and more fast. When a percentage of about 60 has been reached, the colony does no further increase in size, and some time later the number of infested stalks goes down rapidly (fig. 3). From a number of observations of the same kind the conclusion may be drawn that the percentage of parasitism by *Encarsia* is a characteristic of high prognostic value; once an infestation of 40 or 50% has been reached, insecticidal control must be considered to be superfluous, if not injurious.

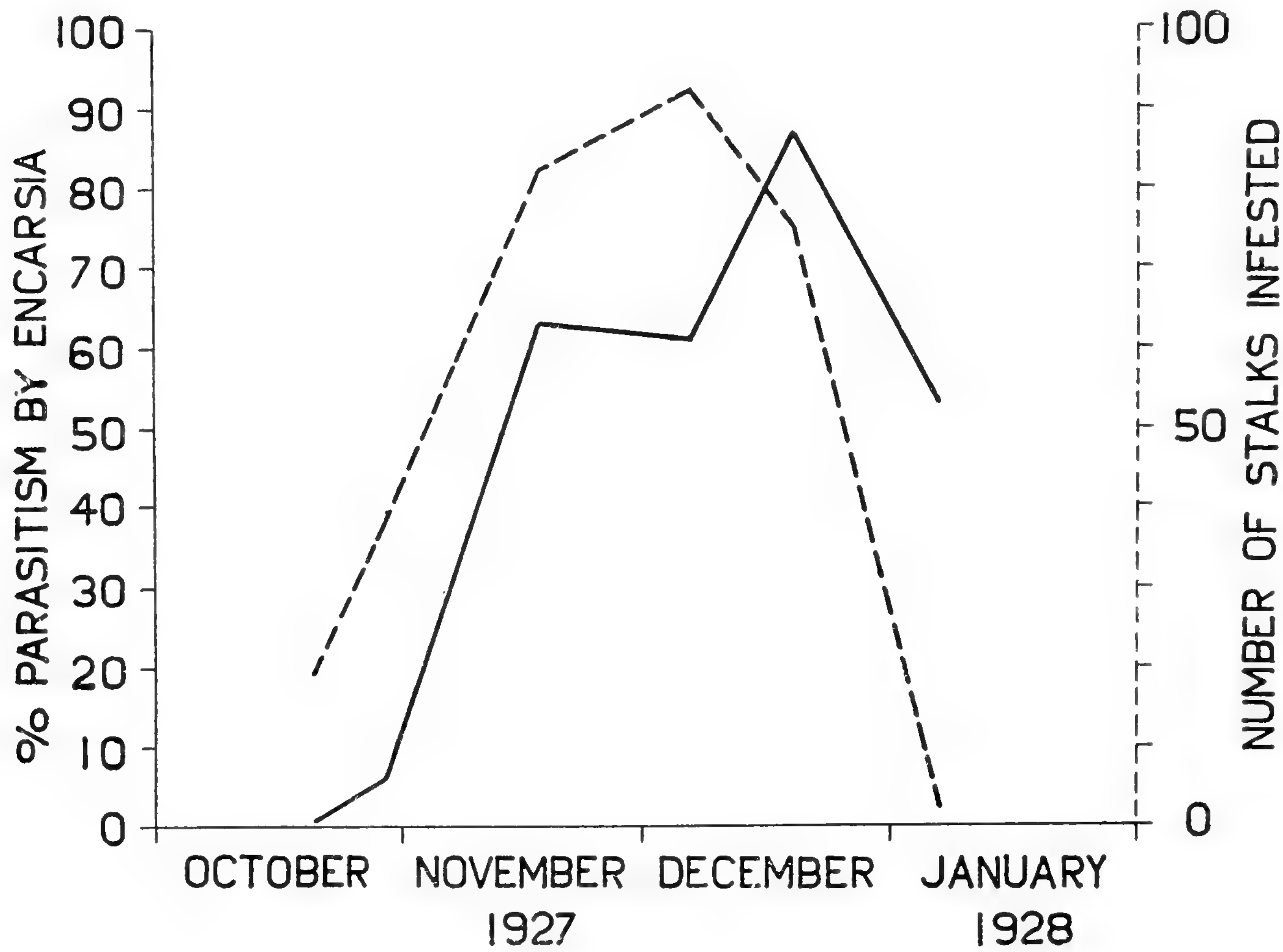


Fig. 3.

Fig. 3. — Percentage of parasitism by *Encarsia* and increase and decrease in size of one colony of *Oregma* (colony No. 15 of the plantation Barongan).

In all seasons the percentage of infestation of each colony is continually increasing; when a slight decrease of the percentage was observed, it afterwards always turned out to be followed by a rapid increase, so that we may assume it to be due to inaccurate sampling. — I do not dispose of enough data to decide whether this increase of the percentage of parasitism can be accelerated or slowed down by climatic influences; canegrowers have often suggested that heavy rainfall has a destructive influence on the lice (or, as we might suppose now, a favourable influence on *Encarsia* *), but without any doubt this influence has been overestimated considerably. It is a well established fact that in the same field some of the colonies may increase considerably, whilst other colonies are going down

*) Cf. W. Dwight Pierce, A new interpretation of the relationships of temperature and humidity to insect development (Journal of Agricultural Research, Vol. V, 1916, p. 1183), and Hefley, Differential effects of constant humidities on *Protoparce quiquemaculatus* and its parasite *Winthemia quadripustulata* (Journal of Economic Entomology, Vol. XXI, p. 213, Febr., 1928).

rapidly; in such a case the first mentioned colonies always turned out to be poor in *Encarsia*, whilst the latter invariably were parasitized heavily. A few instances of colonies, all from the same plantation (Ketanggoengan West) and therefore all under the same or nearly the same climatic conditions, are given in Table II, grouped according to the initial percentage of parasitism. In this case the size of the colonies was expressed in terms of the number of leaves infested.

Table II. Increase or decrease in size of different colonies, grouped according to the initial percentage of parasitism by *Encarsia flavoscutellum*.

Colony No.	Percentage parasitism on Nov. 25—26	Number of leaves infested on	
		Nov. 25—26	Jan. 7
39	0 %	51	275
45	0 %	53	215
46	0 %	59	229
62	0 %	74	192
65	0 %	6	139
38	15 %	13	27
51	10 %	61	76
36	53 %	30	4
53	71 %	64	20

Here again the prognostic value of the percentage parasitism by *Encarsia* is evident; we may conclude safely that the influence of parasitism is much more pronounced than that of rainfall or drought.

After chemical or mechanical control had been applied, I often observed a very marked decrease of the percentage of parasitism. Observations of this kind are collected in Table III; in those cases where two samples were taken after control, both samples are mentioned in the table in order to show at the same time the increase of parasitism of the same colony, when left undisturbed (the third sample generally was taken two or three weeks after the second; no insecticidal control was applied between second and third sample).

It is very probable that this decrease of the percentage of parasitism after insecticidal control must be explained in the following way: the young, unparasitized lice on the newly infested leaves, which are yellowish green and not easily to be seen, have a far better chance to escape chemical or mechanical control than the conspicuous white lice of the older leaves. Therefore, as the older lice often are parasitized to a much higher degree than the young lice on the newly infested leaves, the parasite must be destroyed in far greater numbers (proportionally) than its host. As explained by Thompson *), this must delay the victory of *Encarsia* considerably, or even prevent it. In all probability this is the true explanation of the fact that often insecticidal control seems to do more harm than good. — When a colony is very rich in *Encarsia*, so many parasites will escape

*) Thompson, On the effect of methods of mechanical control on the progress of introduced parasites of insect pests; in Bull. Entom. Research Vol. XVIII, 1927, p. 13.

that no renewed outbreak of the pest will occur. In this case chemical or mechanical control will seemingly have good results, but in reality the fact that no renewed outbreak occurs must be ascribed to the presence of many parasites; in such a case the pest would soon have been subdued completely by *Encarsia* even if no control had been applied. Several field observations have greatly confirmed my opinion that the result of insecticidal control is largely dependent on the number of parasites left, this measure evidently being insufficient when applied to colonies poor in *Encarsia* and rather superfluous in colonies rich in *Encarsia*.

Table III. Decrease of the percentage parasitism after chemical or mechanical control.

Cane estate	Number of colony	Percentage parasitism before control	Percentage parasitism after control
Boedoean	8	38 %	2 %— 8 %
Djatie	4	63 %	32 %—63 %
"	5	76 %	25 %—62 %
Gondang Winangoen	13	79 %	48 %
" "	14	36 %	3 %
" "	15	45 %	14 %
Ketanen	1	10 %	0 %— 0 %
Ketanggoengan West	36	84 %	11 %—53 %
" "	37	76 %	0 %— 0 %
" "	38	43 %	4 %—15 %
" "	39	32 %	0 %— 0 %
" "	50	81 %	1 %
Krian	2	78 %	0 %
"	3	52 %	3 %
"	6	14 %	0 %
"	11	81 %	17 %
Maron	2	16 %	0 %
Ngelom	14	38 %	2 %
Pandjie	1	51 %	6 %—43 %
Perning	2	71 %	22 %—45 %
"	3	30 %	18 %
"	4	54 %	5 %—69 %
"	5	55 %	5 %—41 %
"	8	80 %	26 %
"	12	33 %	13 %—22 %
"	41	82 %	20 %
Poendoeng	5	88 %	39 %
Somobito	1	37 %	6 %—57 %
Sroenie	13	48 %	11 %—68 %
"	16	37 %	5 %—73 %

These considerations led me to adopt a new method of combating *Oregma*, the principle of which is to help *Encarsia* by discarding all insecticidal control of colonies rich in *Encarsia* and by transferring *Encarsia* to those colonies where it did not yet appear of itself.

For this purpose, before applying insecticidal control, the percentage of parasitism is determined for each colony separately. If 40% or more of the lice are parasitized, then the whole colony is left undisturbed. If 20—40% of all lice are parasitized, then the lice on the newly infested leaves, which in this case are usually very poor in *Encarsia*, are exterminated as completely as possible, whilst the older, heavily parasitized parts of the same colony are left undisturbed; and in case the colony is

very poor in *Encarsia* (0—20% parasitism), then in the first place insecticidal control is applied and afterwards *Encarsia* is transferred to it in order to prevent a renewed outbreak of the pest. We may assume that a greater or smaller number of lice always will escape control, and by transferring *Encarsia* we are able to keep the remaining lice in check. Very small colonies can be subdued by merely transferring *Encarsia;* in the case of greater colonies this measure must be preceded by insecticidal control.

In a few experiments the results obtained by this method were compared with the outcome of the old methods of control by treating the two halves of one field in a different way. The new method turned out to have decidedly better results, the damage done to the cane being less and the expenses much smaller. In the next seasons the new method will be put to the test in large scale experiments: the area of 8 or 10 cane-estates is divided into a larger and a smaller part, the old method being applied to the former and the new (combined) method to the latter part. If also in these experiments the new method will turn out to be the better, special measures must be taken in order to secure a ready and reliable investigation of the lice-samples by the staff of each cane-estate; fortunately the determination of the percentage-parasitism is a very easy matter, which can be done quite satisfactorily by natives. Moreover, those colonies which are heavily parasitized can be easily recognized by the great number of adult parasites moving about between the lice.

Although the combined method of insecticidal and biological control has not yet been tried on a large scale, our small scale experiments have given results so promising that it seemed worth while to publish our results, however preliminary they may be. Moreover, I think it not improbable that a similar method of utilizing n a t i v e parasites may prove useful in the case of other pests of tropical one-season crops, where a good reproducing native parasite is handicapped by rotation of crops.

Weather and the Non-burning of Trash in Borer Control in Porto Rico*).

George N. Wolcott, Estacion Experimental Agricola, Lima, Peru.

Our knowledge of the effect of such factors as rainfall and the non-burning of trash on the sugar-cane moth borer, *Diatraea saccharalis* Fabr., has been obtained in Porto Rico largely because only there are such varying conditions of climate and methods of cultivation of sugar-cane present in a very restricted and readily accessible area. The wide variation in conditions under which sugar-cane is grown in Porto Rico permits of observations on the effect of these conditions, not possible, or certainly less easily noted, in much larger, but more homogeneous countries.

Fields of cane near Mameyes, close to the tropical rain forest of the Luquillo Forest Reserve, may receive as much as 100 inches of rainfall in a year, while other fields of cane, along the south coast of the island, depend largely upon irrigation for their water supply, the rainfall in some years being as little as 20 inches, or less.

For many years, there has been an intermittent discussion as to the advisability of burning or non-burning trash, primarily as it relates to the control of the borer. In most countries where it has been very vigorously discussed, the custom of burning the trash is so firmly fixed in plantation practice, that no fields where it has not been burned are available for making the comparisons necessary to determine its effect. In Porto Rico, on the contrary, at some Centrals it has been customary to burn the trash, while at others, often with fields immediately adjacent, it has been just as distinctly and invariably the custom *not* to burn, and to take every care that the trash, even accidentally, is *not* destroyed by fire. Such conditions make it a comparatively simple matter to determine what actually is the effect on the borer of this difference in method of disposal of the trash. It merely required patient and persistent effort to make possible the results reported by the writer, which showed that,

1. "in general, the per cent of infestation was inversely proportional to the rainfall; that is, an abundance of rain meant few borers, and little rain meant many borers;
2. "in 1915 the infestation of *Diatraea* was 100% higher by localities in fields where the trash was burned and in 1916 it was 50% higher, than in fields where the trash had *not* been burned."

Entomologists in other countries have not had the unique opportunity presented in Porto Rico to collect the necessary data on these points.

*) Approved for presentation at the Fourth International Congress of Entomology by the Temporary Superintendent, Estacion Experimental Agricola, Lima, Peru.

The absence of any extensive amount of corroborative evidence from these countries even now available, 12 years later, is surely not due to lack of interest, for the non-burning of trash seems to offer the most hopeful, albeit partial, solution of the borer problem. It is rather due to lack of opportunity inherent in the uniformity of the climate and methods of cultivation of cane in other countries.

Although it is seldom possible to obtain parallel comparative data from other cane-producing countries, yet all evidence seems to indicate that the results obtained in Porto Rico are equally applicable in these countries. In Peru, for instance, cane is entirely dependent for water upon irrigation, as there is absolutely no rainfall, ordinarily, in the coastal valleys where all the larger mills are located. Also, because of insufficient labor, the cane is burned before cutting to make harvesting easier, and any debries remaining in the field after harvesting is again burned, so that destruction of trash is complete. That is, from the theoretical standpoint one would say that conditions are most favorable for a very heavy infestation by the borer.

The facts amply corroborate the theory. The infestation by borer is so extensive that no mature stalks of cane can be found that are not attacked. Indeed, all ordinary methods of measuring the abundance of the borer must be discarded in Peru, for what might be considered comparatively clean cane will have over half its joint infested, and instances have been noted where large areas of nearly mature cane have been killed by the borer. Such cane will average possibly one borer per joint in the lower half of the stalk, but the upper half will be so largely rotted with multiple infestation in every joint that only the rind holds the stalk together. Such infestations occur in plant-cane, and the planter ordinarily claims that the very heavily infested areas are alkali spots.

It may be true that an alkali soil does so change the chemical composition of the cane that it is more attractive to the borer, or is more susceptible to borer attack. No careful observations have ever been made on the effect of the mechanical and chemical composition of the soil on the infestation by the borer of cane growing in such soils. There may be some connection. One ordinarily thinks, however, that it is no more definite than that it is the strong, healthy, vigorously growing canes which are most readily attacked by the borer, no matter how such conditions of vigor may be produced. In the tropics at least this is ordinarily considered the reason why plant-cane is more heavily infested than ratoon-cane. We really know nothing of the chemistry of cane as it affects borer infestation, or whether it does have any effect at all.

There is no question, however, that certain varieties of cane are less infested by the borer than others. Yellow Caledonia and Cavengirie, despite the long season (18 months) necesarry for them to reach maturity, have the lowest infestation of any canes grown in the moister sections of the island (of Porto Rico). In this connection it should be noted that B-3412, which has the lowest infestation per stalk in the dry sections of the island, is also a long-season cane.

"The characteristic of these varieties which is responsible for the difference in borer infestation is not at once apparent. Yellow Caledonia, Cavengirie and B-3412 are long-season canes with low sucrose content until they mature, while Chrystalina has considerable sugar even when im-

mature, and this checks up fairly well with the data at hand. But D-117, with only a slightly shorter season than B-3412, is nearly twice as heavily infested. The hardness of rind, or high percentage of fiber and difficulty of milling, which is also characteristic of the canes with low borer-infestation, would seem to be more the sort of thing that would affect an insect which chews and bores into their stalks, but Otaheite, the easiest milling cane, does not have the highest borer infestation. B-3412 and D-117 have very nearly the same amount of fiber. Altho the borer may live and complete its development in the older and harder portion of the cane, the majority of the caterpillars live in the young shoots or in the younger growing top of the older cane, which is soft and comparatively easily bored in all varieties. It is quite possible that the varying degrees of acidity, or possible esters of the cane juice, as affected by variety and rainfall in these growing portions of the cane, is the determining factor favoring or retarding its development, but no data are available for judging this."

All this discussion is quite out of date in Porto Rico, where none of these varieties are now grown on any considerable scale. Indeed, in most countries new varieties are being introduced and are rapidly supplanting the old. We should know how the borer reacts to each of these varieties, and what is vastly more important, why it is more abundant or less abundant than in the canes that have previously been grown. It is too much to hope in the immediate future for a commercially valuable cane that will be immune to borer-attack, but if we know *why* any kind of cane is partially immune, the possibility of obtaining a more nearly immune variety may be greatly simplified.

Literature.

Wolcott, G. N., The influence of the Variety of Sugar-Cane on its Infestation by *Diatraea saccharalis,* and the other Factors Affecting the Abundance of the Moth Borer; in Journ. Dept. Agr. Porto Rico, Vol 6, No. 1, January 1922, pp. 21—31, 2 figs., 4 refs, October, 1922, San Juan.

The Method of Controlling the Sugar-cane Borer by attracting adults to heaps of trash.

Dr. K. Kunhi Kannan,
Entomologist, Department of Agriculture, Mysore State.

In this paper, which I am enabled to present to you by courtesy of the Program Committee of your Conference, I propose to describe very briefly the method of controlling the sugar-cane borer devised by me, which has been tested for the last seven years in Mysore and has been found cheap, simple and fairly effective in the conditions prevailing in the State. The method is based on the universal habit of moths of hiding during the day and flying about during the night.

Sugar-cane is planted in Mysore any time between January and May and grown under what are called tanks, which are reservoirs of water made by throwing a bund *) across the middle of a valley in one half of which the water from the rains accumulates, while in the other half wet crops like sugar-cane and paddy are cultivated. In an area of this kind, varying from a few hundred to a thousand or more acres, all stages of growth of cane may be seen between January and May: old cane being harvested, fields being prepared for cane to be planted, young cane from a few inches to a couple of feet in height. The newly planted fields are usually quite bare of vegetation except for the shoots from the planted setts. The fields have narrow bunds from ½ to ¾ of a foot broad and covered with grass.

The trash method is effective against four species of borer moths, which have not yet been correctly determined, but which may be provisionally identified as *Diatraea auricilia, Diatraea venosata, Sesamia inferens,* and *Emmalocera depressella.*

Of these the last, *Emmalocera depressella,* is a root borer and is of little consequence in Mysore.

Diatraea auricilia is the most common; *Diatraea venosata* is comparatively rare; and *Sesamia inferens* is found in good numbers in localities where its alternative food plant, *Andropogon sorghum,* is grown in the neighbourhood of cane. Damage by these three species is confined to the first two months of growth of the cane when the larvae kill the growing shoots, causing what are known as "dead hearts". There is no attack in later stages until September or October, when growth of the cane has ceased. Caterpillars of the three species may then be found boring in the top or hibernating.

---

*) embankment.

The borer moths, from old cane still being harvested or from infested tops planted, emerge and fly about for pairing and then egg-laying. During the first night of their emergence most moths complete copulation and a few may lay the first batch of eggs. These moths have to seek shelter the following morning and will crawl into the crevices or other shelters as may be found in the field itself, along bunds or in the fields of old cane. It was thought that if shelters were provided at convenient places in the young cane fields themselves, the moths might be tempted to seek them out for passing the day in preference to those far away. Accordingly small heaps of cane trash were placed in a cane field at the rate of five heaps per acre, and moths looked for, and these were indeed found in the ground below the heap and rarely flew away on disturbance.

The preliminary trials having been encouraging, plans were laid for the collection and destruction of moths this way in one of the Government Farms where 50 per cent. of the seedlings used to be bored and the cutting out of "dead hearts" had proved of no avail. Five heaps were placed on each acre of cane and boys went round every morning for two months collecting the moths. The result was that the number of bored shoots was reduced from 50% to as low as 2%. A boy could cover 5 acres in a day and his wages per day were no more than 3 annas. The cost for two months was about Rs. 2 As. 4 or a little over ¾ of a dollar per acre.

Since then the method has been followed year after year, and damage has never gone beyond 2 to 10% as against 30 to 80% in canes grown in the locality. In some of these years the conditions were particularly exacting. Cane was planted late or suffered from want of water, or the fields had stacks of green manure cut and arranged along the rows of cane. The remedy has stood these tests fairly well. It has been tried in three other localities in Mysore with equally good results.

The moths collected from the heaps were of both sexes. The females were allowed to lay eggs after capture, and the average for 28 moths was 108 eggs. The average for moths reared in the insectary and as determined by dissection was 200. In noting this difference, which is fairly substantial, the following considerations have to be borne in mind. The average of 108 is from moths collected from trash-heaps placed in a few fields out of several 100 fields which had no heaps, and therefore there was the possibility of moths being included in the collection which sought the shelter of the heaps on the 3rd or subsequent days of emergence and not on the second. This factor can be said to have been eliminated only when the area of daily collection is sufficiently wide for capturing all moths that emerge in the area and sufficiently isolated to prevent moths from coming over from other areas. This experiment has not been attempted on account of cost.

What has been said above relates to *Diatraea auricilia*, the most serious of the moth borers of cane in Mysore, but the observations apply also more or less to the other two species.

It is obvious that there can be no thought of complete eradication of the pest. There is not only the possibility of about 40% of the eggs being laid the first night, i e. before moths seek the shelter of the heaps, but also of a few moths seeking ordinary shelters outside the ones provided, even though repeated search has failed to detect any such. At

the same time a reduction in the borer population as high as 60% of the total must follow directly as a result of the application of the remedy, and what is left over must be further diminished by the enemies, of which there is a parasite for the egg, a fly and a braconid for the larva, and two species of robber-flies, two of dragon-flies and one of tiger-beetles for the adults.

Repeated attempts have been made to perfect the method. Even though the remedy is very cheap, its effectiveness depends on the care with which moths are collected, and efforts were directed to the construction of traps made of trash which, while allowing the moths to come in, prevent their getting out. It has been found difficult to devise a trap of this description, because (1) moths, without getting in, find shelter enough on the outside of the traps in the inevitable folds of cane-leaves to be found, (2) in getting out of their shelters in the evening to start flying they are slow and deliberate and there appears to be no mechanical surrender to impulse, and (3) employment of any additional material like mosquito- or wire-netting, palm-fibre, etc., seems to diminish the attractiveness of the trap. Hope, however, is not abandoned, and fresh attempts will be made to devise a suitable trap.

In the above account no reference has been made to two other borer moths, viz., *Scirpophaga xanthogastrella* and *S. monostigma*, both of which attack cane, but in small numbers. Unlike the others, their caterpillars may attack the growing point any time during growth, but usually young canes under two months suffer worst. The moths are not attracted to trash-heaps, but being shining white and having the habit of sunning themselves, they are conspicuous objects in the young cane-field and are easily caught by hand and killed, when boys go round to capture moths from trash-heaps.

Before concluding I should like to record that, besides the moth borers, several other insects seek the shelter of the trash-heaps. Among these *Gryllotalpa sp., Earias fabia, Heliothis obsoleta, Herse convolvuli,* have occurred in sufficient numbers to warrant trial of trash-heaps as a method of control in situations where conditions in respect of cleanliness of the field and absence of weeds are similar to those of the young cane-fields in Mysore.

The Pink Bollworm in Haiti.*)

George N. Wolcott, Entomologist, Estacion Experimental Agricola, Lima, Peru.

The factors which make possible the profitable and commercial production of any agricultural crop are numerous and varied. In many cases, especially where the margin of profit is small, the introduction of a single new unfavorable factor may be decisive in determining whether a crop will continue to be grown in a particular locality, or its production abandoned because of the excessive cost of overcoming this one factor. Everyone can think of such instances, where the gradual exhaustion of the virgin fertility of the soil, the increasing alkalinity of irrigated lands, the accidental introduction of a single serious insect pest or of a single destructive plant disease has been sufficient to cause a revolution in the agriculture of a community. It is difficult to appraise properly the importance of these factors. They are not of the spectacular nature that gets into newspapers, nor the traditional matter of which history is supposed to be composed. The people most intimately concerned can not be convinced that something which they know has vitally affected their own fortunes, and those of all their neighbors, is the equivalent, in historical perspective, of many a minor war. Even the scientist himself finds that, because of early training, he cannot be sure that he is not overestimating such single factors as the spread of the Mosaic Disease of Sugar-Cane in the cane-growing countries of the world, or the advance of the Mexican Cotton Boll Weevil in the Southern United States.

But whatever their absolute importance, the advent of new and seriously destructive insect pests and plant diseases seems to be becoming increasingly common in recent years. The many changes and adaptations in cotton cultivation that ensued from the spread of *Anthonomus grandis* in the South have recently been duplicated in most of the other cotton-producing countries of the world by the appearance of another insect pest, the Pink Bollworm. The strenuous measures that are being taken by the Federal Horticultural Board to keep this pest out of the United States, and to exterminate it whenever it gains a foothold here, testify to a well-justified appreciation of the destruction that it may cause. Thus, it may be considered a most exceptional phenomenon that, in one cotton-producing country at least, its appearance was marked by no decrease in production, no change in methods of cultivation, and that year after year it fails to produce any noticeable damage, so that most of the cotton growers are entirely unaware of its presence in their fields.

---

*) Approved for presentation at the Fourth International Congress of Entomology by the Temporary Superintendent, Estacion Experimental Agricola, Lima, Peru.

Cotton has been grown in the southern portion of the Republic of Haiti for many years, and it is so well adapted to the country that it thrives under even the most primitive and limited efforts at cultivation. Indeed, it can scarcely be considered a cultivated crop, in any ordinary sense of the word, for all the care that it receives from the grower, aside from picking the crop and transporting it to a market, is that, when the crop has been harvested, the bushes are cut down and burned, together with any other high weeds, bushes or trees that may happen to be in the fields, so that all have an even start to "ratoon" from their roots. Incidentally, cutting out and burning all the aerial portions of the cotton plants each year exercises a most beneficial effect in preventing the white scale, *Hemichionapsis minor* Maskell, from becoming sufficiently abundant in the cotton fields to cause any appreciable damage, but whether it is purposely done for this reason, or merely because of tradition and custom, can not be stated.

Without attempting to discuss the botanical characters of the native Haitian cotton, or to consider whether, because it often displays all sorts of variations from the rather long-linted, free-seeded norm, it represents a single species or variety, or several, it may be stated that in one respect, at least, it shows almost surprising uniformity. No matter at what season of the year it may be planted in Southern Haiti, the plants do not begin to produce flowers until December. Bolls begin to mature late January on plants growing from seed, or possibly a week or two earlier on ratoon plants. Within two months, or three months at the most, all the bolls have matured and the picking season is over. The older leaves drop from the plants as the bolls mature, so that only bare stalks and empty bolls are to be seen by spring. After these aerial portions have been cut down and burned, the usual spring rains cause an abundance of new shoots to spring up. If weather conditions are just right, a partial second crop, or rather a considerably delayed part of the first crop, may be matured late in the spring, but this is quite exceptional. Ordinarily, only a single winter crop is produced, vegetative growth taking place thruout the rest of the year. The native cotton is admirably adapted to climatic conditions in Southern Haiti, for there is comparatively little rain in this section of the country during the winter, when it is ripening its bolls. On the contrary, it is poorly adapted to those of the Plaine de Nord, where heavy rains often occur during the winter months, delaying the maturing of the bolls and causing internal boll rots, so that commercial production of native cotton in this region has not been a success.

It is definitely known that the pink bollworm, *Pectinophora gossypiella* Saunders, was present in the Cul-de-Sac plain of Haiti in 1923, and the writer, by personal inspection in the summer of 1924, determined that it was present in all parts of the Republic at that time. Most surprisingly, however, practically all of the records of the presence of the pink bollworm in Haiti made then or later were in bolls of Sea Island, or some other imported variety of cotton, and great difficulty was experienced in finding infested bolls on bushes of native cotton, which forms the great bulk of the commercial crop. Indeed, if one tries to demonstrate the presence of the pink bollworm in Haiti, it takes hours of search to find infested bolls of native cotton. This is so very extraordinary, indeed so very different

from the record of the appearance of the pink bollworm in other countries, that it was only after observations extending over three years that it was finally reported as being unquestionably so. *)

The scarcity of the pink bollworm in native cotton is not due to exceptional climatic conditions in Haiti, for other varieties, such as Sea Island, Violet, Peruvian and Meade growing there, are heavily infested, just as they are in other countries. Nor is it, in any large measure at least, and as might at first appear likely, due to the short crop season of the native cotton. As January to March are the only months when native cotton has bolls on which the larvae might feed, the absence of a suitable host during the remainder of the year might, and in some cases very probably does, exercise a rather considerable check on its increase. Despite the fact that native cotton is the only commercial variety successfully grown in Haiti, yet thruout the country there are scattered plants of Sea Island cotton, and of a purplish variety called "Violet". These are not restricted to the winter months for maturing bolls, and almost invariably the bolls on these plants are heavily infested. In fields of native cotton near-by, or even interspersed with such plants, or near experimental plantings of Peruvian or Meade cotton, the bolls of the native cotton are practically as free from pink bollworm injury as tho no heavily infested plants were near. The contrast between field after field of native cotton so lightly infested that one can only by persistent search find an average of one typically infested boll an hour, and a field of Meade cotton so heavily infested that uninfested bolls are found only after protracted search, is too striking to be ignored. Such high resistance of the native cotton is not merely an occasional accident caused by some vagary of climate, by exceptional care in cultivation, fumigation of seed, or carrying out some other of the recommendations designed to limit the depredations of the pink bollworm, but is the regular and accepted rule, and occurs without any conscious effort on the part of the persons growing cotton.

To determine with greater certainty what are the factors responsible for this apparent immunity of native cotton from infestation by the pink bollworm, observations on an experimental planting of cotton at the Experiment Station of Service Technique, at Damien Farm, were made during 1927.

It seemed possible that there might be some characteristic of the bolls that made those of the native cotton unattractive to the moths as a place for the deposition of eggs. Previous investigations as to the place where the moth lays her eggs are not in entire agreement, and comparative observations on the rough bolls of Sea Island cotton and the smooth bolls of Meade indicate that the female moth does show a very decided preference for the rough bolls, the pits of which are almost invariably chosen as a place in which to deposit her eggs. On smooth bolls one can find very few eggs, even in the carpel divisions, yet the bolls of Meade cotton proved to be almost exactly as heavily infested by the larvae as the bolls of the Sea Island. The smoothness of the Meade boll is no protection from pink bollworm attack, while the native Haitian cotton often has a much rougher boll than the Meade, altho seldom approaching in roughness

*) Wolcott, George N., "Haitian Cotton and the Pink Bollworm"; in Bull Entom. Research, Vol. 18, Pt. 1, pp. 79—82 September, 1927, London.

the Sea Island. These observations seemed to lead nowhere, and were discontinued.

A considerable number of commercial and other varieties of cotton were grown by Dr. H. D. Barker, Plant Pathologist and Botanist for Service Technique, in an experimental planting at Damien Farm. They were planted in April, 1927, in parallel rows, Rows 0 and 1 and adjacent volunteer plants of native cotton being used as check. In December, observations were made as to their comparative infestation by the pink bollworm, the data being obtained from ripe bolls from which the lint had previously been picked. At this time the native cotton had just begun to bloom, and by the latter part of January, when the native cotton had just begun to put out ripe bolls, very few bolls of the same age were present on the bushes of the other varieties. Indeed the data of infestation between native and other varieties are at no time exactly comparable. The other varieties merely served to propagate large numbers of pink bollworm moths, which in January were practically forced to transfer their attention to the bolls of the native cotton, because there were no young bolls on the other varieties. It should also be emphasized that not only was no control of the pink bollworm attempted in this experiment, but all lint and bolls from the native cotton was dropped on the ground, so that any stages of the insect present in this material were left there. Thus, any decrease in the abundance of the pink bollworm is most decidedly not due to their being killed or removed from the region of the experiment.

Table 1.

Comparative Infestation by Pink Bollworm of Several Varieties of Cotton.

Variety	Per cent of ripe bolls infested by pink bollworm	
	December 1927	January 1928
Pima	52 %	84 %
Sea Island (Dahomey)	52 %	82 %
Sea Island (Porto Rico)	47 %	no fresh bolls
Meade	47 %	83 %
Peruvian	46 %	70 %
Koroniba	42 %	72 %
Hartsville 20	30 %	no fresh bolls
Over-the-Top	27 %	no fresh bolls
Mebane	19 %	no fresh bolls

On January 23rd, 41 bolls of native cotton had ripened on the bushes of native cotton, and of these 17% were infested with pink bollworm. It was on this date that the observations on the other varieties were made which are given in the preceding table, showing from 70% to 84% infestation, and these are the only strictly comparable data. On the 25th, 220 bolls of native cotton had ripened, and of these 39% were infested, on the 26th, 122 bolls were ripe, and of these 51% were infested. This is the maximum infestation recorded on native cotton. Of the bolls examined on the 28th, the infestation had dropped to 33%, and the average for the first thousand bolls examined, January 23rd to 30th, was 37%. These observations were continued, and the result on each successive thousand bolls is given in the following table.

Table 2.

Infestation by Pink Bollworm of Ripe Bolls of Native Haitian Cotton on Bushes Grown Immediately Adjacent to Other Varieties.

First Thousand Bolls, examined	January	23 rd to 30 th	37%
Second „ „ „	February	1 st to 11 th	28.6%
Third „ „ „	February	13 th to 15 th	19.2%
Fourth „ „ „	February	16 th to 22 nd	19.5%
Fifth „ „ „	February	23 th to 28 th	14.7%
Sixth „ „ „	March	3 rd to 10 th	14.2%
Seventh „ „ „	March	16 th to 27 th	24%

The increase in infestation in the last thousand bolls examined, may possibly be due to the entire absence of bolls of other varieties which might be infested, for a few fresh bolls had appeared on these plants during the latter part of February or early in March. Or it may be due to the normal end-of-the-season increase in abundance of the pink bollworm, for towards the end of the picking season it is possible to find pink bollworm-infested bolls in commercial fields at the rate of sometimes as many as three or four in an hour's search, instead of one, if one were lucky and happened to find it, in the same length of time at the beginning of the season.

These data would thus appear to indicate that:

1. when foreign varieties of cotton are heavily infested with the pink bollworm and they cease to produce bolls that might be infested, bolls of native cotton are attacked. That is, the pink bollworm can be forced to attack native cotton;
2. native cotton is so unattractive to the pink bollworm that an artificially induced heavy infestation tends to decrease as the season advances. This is so unprecedented as to mark native Haitian cotton as being unique among all known varieties of cotton.

Summary.

Although the Pink Bollworm has been present in Haiti for at least five years, its presence has in no way affected the commercial production of native cotton. This appears to be due to the fact that only foreign varieties of cotton are attacked by the Pink Bollworm, the native cotton being practically immune from infestation. The cause of this comparative freedom from attack has not yet been determined, but it appears to be inherent in the cotton itself and not due to outside factors. When grown immediately adjacent to foreign varieties, the native cotton is, by comparison, lightly infested, but even this infestation tends to die out as the season advances.

The Pink Bollworm Situation in Australia.

F. G. Holdaway,
Entomologist, Council for Scientific and Industrial Research, Canberra, F. C. T., Australia.

(With 2 text-figures.)

To anyone who has followed the literature on pink bollworm during the past few years, in particular as it applies to Australia, the situation must have appeared particularly confusing.

Two pink bollworms have been confused. The one occurs only in the North, North-west and West of Australia. The other occurs only on the East coast.

From Western Australia *Pectinophora gossypiella* was recorded by Meyrick (28) from material collected by Mjöberg at Broome in 1911. It was also collected by Newman at Broome, Port Hedland, Roebourne and Carnarvon in 1923 (38). In the Northern Territory, Hill obtained it in 1912 in the Roper River district, and in 1914 and 1915 in other parts of the territory.*) These specimens were identified by both Meyrick and Turner, and recorded by Turner (37) and Hill (22). It has also been recorded from the Northern Territory by Tryon (38) and the writer (23).

In addition to these records from Western Australia and Northern Territory, Ballard has on several occasions (4) (5) (6) (7) referred to the presence of *gossypiella* in Queensland. The writer, however, has maintained that the Queensland pink bollworm is not *gossypiella*, but a new species in all probability indigenous to Australia (23).**)

Reference by Ballard (12) to the occurrence of *gossypiella* in Queensland even after the evidence for the Queeensland insect not being *gossypiella* had been published, must only have served to accentuate the confusion.

It is hoped that the present contribution, by supplementing the earlier evidence (23), will serve to indicate the actual state of affairs.

Generic Synonymy. Before proceeding to the main discussion a brief review of the generic synonymy will be of advantage. The "pink bollworm" of economic literature up to 1926 has reference to the insect described by Saunders from India in 1843 as *Depressaria gossypiella* (33). The species was later included by Meyrick in the genus *Gelechia*

*) Personal communication.

**) In a joint publication under my name (8) reference is made to *gossypiella* in Queensland. I have never subscribed to such an opinion. The reason for this inclusion in the publication is that my departure from Queensland necessitated the final form of the paper being left to the co-author.

and much of the earlier literature refers to it under this name. In 1917 Busck (16) erected the genus *Pectinophora* for *Gelechia gossypiella* and *G. malvella* Zeller. Meyrick had in 1895 (26) created the genus *Platyedra* for the single species *Gelechia vilella.* In 1918 (27) he considered this genus to include *gossypiella.* It would thus appear that, if the genus *Platyedra* included *gossypiella,* then Busck's genus *Pectinophora* would become a synonym of *Platyedra.* However, the evidence seems very strong that *gossypiella* is not congeneric with *vilella* (16) (21), and hence that Busck's *Pectinophora* is valid and the correct genus for *gossypiella.*

The Genus *Pectinophora* in Australia.

As mentioned previously, *P. gossypiella* was collected in Western Australia as long ago as 1911 and in the Northern Territory in 1912. In view of the fact that both Meyrick and Turner, who identified these specimens, later identified the Queensland pink bollworm as *gossypiella* also, these identifications must be regarded with some slight doubt. However, examination of larvae from these two localities in 1923 indicates that there is little doubt that *gossypiella* occurred in these regions at that time, and hence also that the material collected in 1911 and 1912 in all probability was *gossypiella.* However, absolute proof can only be obtained after examination of the genitalia of the adults.

As far as Queensland is concerned there is no evidence at present of the existance of *gossypiella* there. However, three closely related species do occur there, one of which, *P. scutigera* Hold., has been attracted to cotton wherever the crop has been grown in close proximity to its natural host plant. It is this insect concerning which most of the recent references to pink bollworm in Australia have been made, which, except for the writer's own publication (23), has been incorrectly referred to as *gossypiella.*

The reason for this is evident, when it is realised that adults submitted to microlepidopterists in Australia, Great Britain and U. S. A., could not be distinguished from the adults of *gossypiella,* the larval differences being considered "variations" or at most evidence of a different "strain". However, the larvae and pupae differ in so any respects from those of *gossypiella* that the writer in 1926 proposed for the Queensland insect the name *P. scutigera* in support of the contention that the insect was a new species indigenous to Australia. This action was supported by considerable ecological evidence.

At that time it was felt that it was only a matter of search to find the differences in the adults as well as in the immature stages. These differences have now been found in the genitalia of both sexes, and in such striking contrast with the genitalia of *gossypiella,* that no doubt remains as to the validity of the news species.*)

In addition to the two species of *Pectinophora* already referred to, there are at least two other species whose larvae feed in the seed capsules of various malvaceous plants, but which up to the present have not

*) This final evidence will be published in the near future, in Bull. Ent. Res.

directed their attention to cotton, even though cotton was growing in close proximity to the host plants harbouring the larvae.

These two species occur in Queensland, the one having been found in a region usually from twenty to eighty miles from the coast, though occasionally actually on the coast, as for example on Bribie Island in South Queensland. The other has so far only been recorded from Yamala in Central Queensland about a hundred and sixty miles inland, and where the rainfall is only twenty-five inches per annum. There is little doubt that the former of these, previously referred to as *Platyedra* sp. (scarlet larva) (23), is the species which led Turner to record *gossypiella* from Brisbane, Queensland (37), and the latter is possibly the species which be obtained at Charleville (38).

The former was identified by Turner as *gossypiella* and by Meyrick as "*gossypiella*, geographical and phytophagic form". Its distribution overlaps somewhat that of the Queeensland pink bollworm *P. scutigera*, but the third Queensland species would appear to be restricted to the drier regions of the State.

The evidence on which the Queensland pink bollworm was described as a new species has been set forth in a previous publication (23) and need not be considered in detail here. Suffice it to say that it includes many larval and pupal characters in addition to such supporting evidence as host plants, geographic distribution, ecology, and the presence of other local species of the same genus. The final evidence from the genitalia of both sexes, however, leaves no doubt as to the Queensland pink bollworm being a separate species.

The Original Home of *P. gossypiella.*

Most of the opinions regarding the original home of *P. gossypiella* have had reference to either India or Africa. Dr. Barn, through whom the original specimens of *gossypiella* were obtained from India in 1843, states (33) that "the cotton grown from American cotton seed is attacked in preference to any other". This would suggest that the insect was native to India, the introduced American cotton being more susceptible to attack than the native cotton. Durrant (18), however, placed another interpretation on this and considered it was imported with American cotton. However, for other parts of India he traced its importation to Egyptian cotton. Both these ideas are probably erroneous, and since it is now fairly well established that Egypt obtained the pink bollworm from India about 1907, and since America did not receive it until 1917 (31), it would appear to be native to India.

Vosseler (39), who recorded it from German East Africa in 1904, considered it may be indigenous to East Africa. Its occurrence in Zanzibar (1) as long ago as 1911, and also the recent discovery (20) of another species of *Pectinophora (Platyedra)*, *P. erebodoxa* feeding on *Hibiscus diversifolius* in Uganda, lends support to this idea. Busck (16) states that Africa "apparently is the original home of *gossypiella*", and "the occurrence there as well as in Europe of the only other species *(P. malvella)* of the genus *Pectinophora* is in itself strong support for the theory of African origin".

Willcocks (41), Fletcher (19), Ballou (14) (15) and Marlatt (25) consider India or India and South-eastern Asia as its original home. Elsewhere Willcocks (4) says: "The possibility must not be overlooked, however, that it may belong not only to the Indian region, but also (although improbably) to parts of Africa". He nevertheless inclines to the idea that the insect was introduced into British and German East Africa in cotton seed. This supposition is also made by Ballou (15). However, as far as I can find, there is nothing more definite than these "beliefs" concerning the origin of pink bollworm in East Africa as far back as 1904.

But what of *gossypiella* in North, North-west and Western Australia? And what is the bearing which three other species of the genus occurring in Australia have on the general question of the original home of the genus "cannot exist indigenous in Australia". But *gossypiella* existed in North and North-west Australia, as far as I can find, before cultivated cotton had had its advent there. And as in 1923 it was found in "wild cottons" and other Malvaceae, it would appear highly probable that it was supported by these plants in 1911 and 1912. Moreover, the occurrence of three species in Queensland, one extending for over 1,300 miles along the coast in *Hibiscus tiliaceus* and *Thespesia populnea*, and another in the drier parts inland, and a third in an intermediate climate, is more than suggestive of the genus being indigenous to Australia.

If this is so, how can it be made to harmonise with the idea of Vosseler that it is native to East Africa, and of Willcocks, Fletcher, Ballou, Marlatt and others that India and South-eastern Asia constitute its original home?

There is no evidence to disprove either of these ideas, and there appears to be no evidence to disprove the idea that it is indigenous to Australia. Can it be indigenous to three continents, Africa, India and Australia?

The World Distribution of *Pectinophora* in the light of Wegener's Hyothesis of the Origin of Continents.

In the foregoing section, the question was raised as to the possibility of *Pectinophora* being native to Asia, Africa and Australia. In this connection it is interesting to consider Wegener's hypothesis of the origin of continents as set forth in his "Displacement Theory" (40). A glance at his figures will show that, if this theory is correct, the possibility of *Pectinophora* being indigenous to all three continents becomes a probability. For in the original compact continental mass India, the part of Africa from which *gossypiella* was first recorded and in which a related species has recently been found, and North-western Australia were in close proximity. The presence of *Pectinophora* in all three regions has so far been unexplained except by the supposition that it was native there.*)

Is it a mere coincidence that these three regions should possess identical insect forms?

*) With the evidence available it is impossible to decide whether the three species indigenous to Queensland were connected with the other members of the genus via Northern Australia or South-eastern Asia.

At a symposium on Wegener's hypothesis held at the meeting of the Australasian Association for the Advancement of Science at Perth in 1926 (32), considerable evidence, Botanical, Zoological and Geological, which was more than circumstantial, was advanced in support of the theory. And while the least ready to accept such a theory, even as a working hypothesis, were the Geologists, who would thus find themselves forced to abandon a Geological axiom in the fixity of continents, the consensus of opinion was that, while the theory may be found to be untenable in some respects, at least there was increasing evidence to support its acceptance as a working hypothesis. A similar opinion has been expressed elsewhere by Thornberg (35), who says "that the theory in its entirety will live, is hardly possible: that the principle of the theory will grow into general acceptance is quite probable."

Wegener was of the opinion that India and Australia separated from Africa between the Carboniferous and the Eocene. If we accept

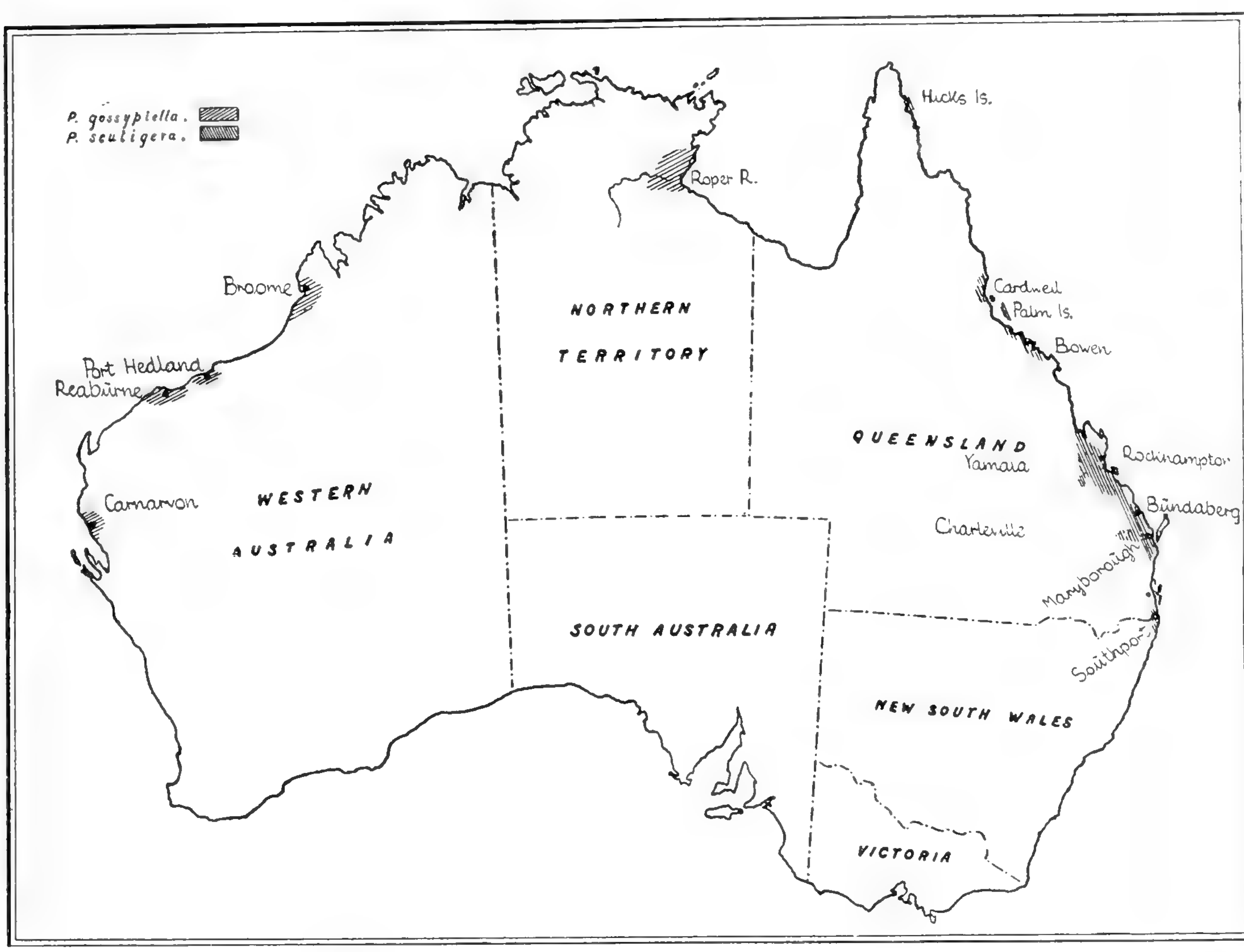


Fig. 1. — The present known distribution of the pink bollworm, and the Queensland pink bollworm.

Tillyard's evidence (36) that the first Lepidoptera appeared in the lower Oligocene, then Wegener's hypothesis does not meet the situation under discussion as far as the period of separation is concerned. This, however, does not rule out the possibility of the theory being in principle true, and if the present discussion serves to put the hypothesis in a somewhat different light it will have served a useful purpose, while at the same time receiving a helpful suggestion regarding an otherwise anomalous situation. In this respect the Gondwana bridge theory in its latest form

recently discussed by Schuchert (34), a strong oponent of Wegener's hypothesis, is not any more acceptable and in some respects is less applicable to the case under consideration.

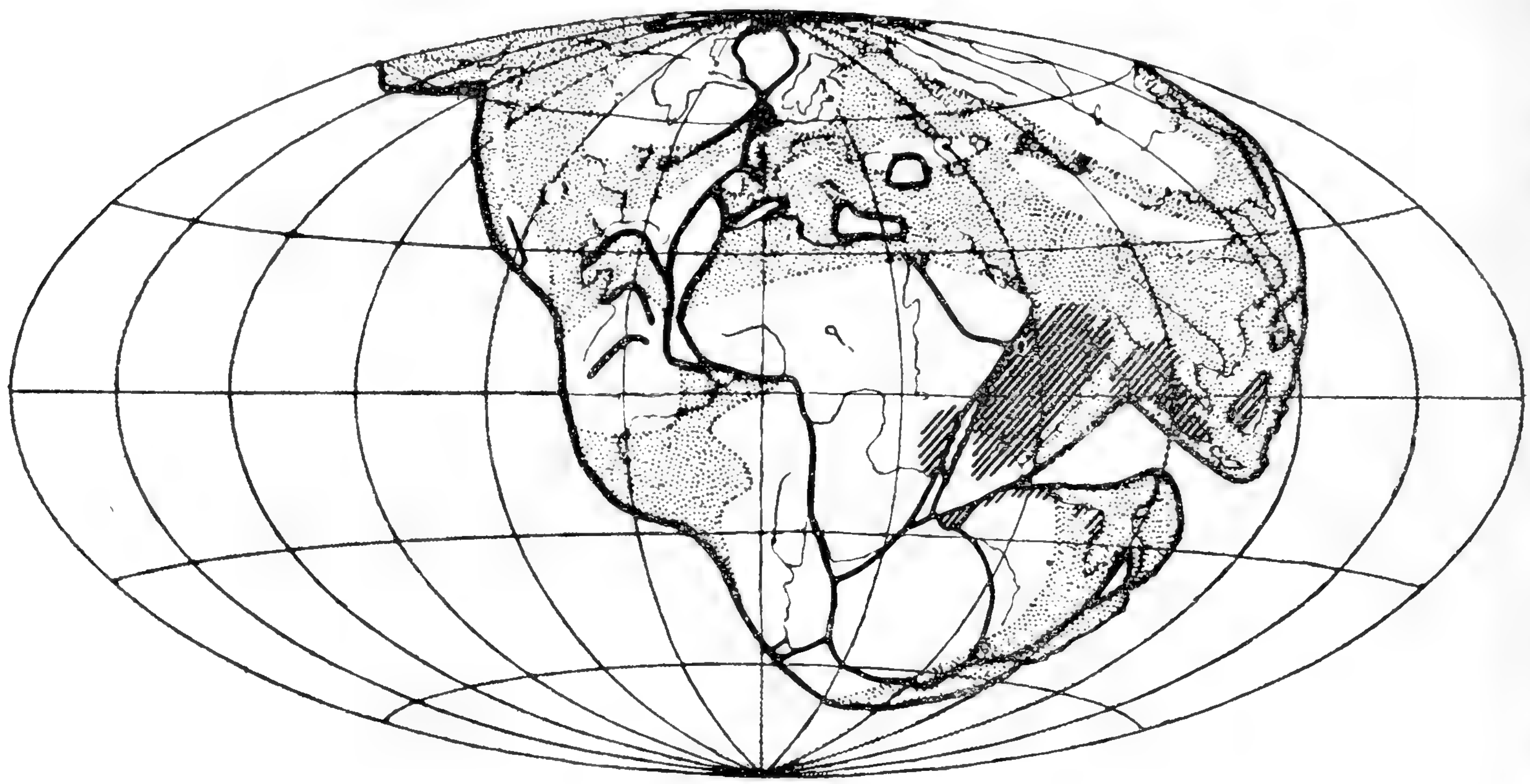


Fig. 2. — The Displacement Theory of the origin of Continents, after Wegener. Regions in which the pink bollworm's presence has been unexplained except on the assumption that it is native there, are shown by cross-hatching.

The question as to what forces could have caused the original break up of the continental mass, and as to whether the origin of the moon from what is now the Pacific Ocean as suggested by Pickering (30), was a contributing factor in the move, must be left to others to solve. On the geophysicists, paleogeographers and geologists must rest the responsibility of refuting Wegener's hypothesis. If it is accepted in its main principles, as seems highly probable, then the present apparent discontinuity of distribution of the pink bollworm will not present the riddle it does at present.

Summary.

The reasons for the present confusion regarding the pink bollworm situation in Australia are discussed. There occur in Australia not only the true pink bollworm, *P. gossypiella,* but also three other species, one of which is the Queensland pink bollworm, *P. scutigera* Holdaway. The original home and the world distribution of the pink bollworm genus are discussed in the light of Wegener's hypothesis of the origin of continents. If Wegener's hypothesis is in principle correct, then the present anomalous situation of the genus being native to Africa, Asia and Australia is explained.

Literature.

1. Aders, W. M. 1911. No. 4. Occurrence of P. gossypiella in Zanzibar. Ref. Durrant (18).
2. — 1914. Entomology in relation to Agriculture; in Zanzibar Protect. Med. Sanit. Rep. for 1913.

3. Anon., 1923. Reported occurrence of boll weevil in Northern Territory (Pink boll worm in N. T.); in Q'land Agr. Journ. 20, p. 101.

4. Ballard, E. 1925. a) Summary of Entomological Reports (Australia); in Emp. Cotton Growing Rev. 2, 1, pp. 40—41.

5. — b) Third Entomological Progress Report (Australia); ibid., 2, 3, pp. 237—240.

6. — c) Fourth Entomological Progress Report (Australia); ibid., 2, 4, pp. 341—347.

7. — d) The Pink Boll-worm in Australia; in Journ. Ec. Ent. 18, p. 641.

8. — and Holdaway, F. G. The life history of Tectacoris lineola F., and its Connection with Internal Boll Rots in Queensland; in Bull. Ent. Res. 17, 4., pp. 329—346. 1926.

9. — 1926. a) Sixth Entomological Report (Australia); in Emp. Cotton Growing Rev. 3, 4, pp. 365—374.

10. — b) The Pink Bollworm (Platyedra gossypiella); in Q'land Agr. Journ. 25, 1, p. 23.

11. — 1927. a) The Entomological problems of Queensland Cotton Growing; in Emp. Cotton Growing Rev. 4, 3. pp. 196—205.

12. — b) Pests of Cotton in Queensland; in Q. Agr. Journ. 28, 6, pp. 589—613.

13. — c) Some Insects Associated with Cotton in Papua and the mandated Territory of New Guinea; in Bull. Ent. Res. 17, pp. 295—300.

14. Ballou, H. A. 1918. The Pink Bollworm (Gelechia gossypiella) in Egypt; Journ. Ec. Ent. pp. 236—245.

15. — 1919. Cotton and the Pink Bollworm in Egypt; in West Ind. Bull. 17, 4, pp. 237—292.

16. Busck, A. 1917. The Pink Bollworm, Pectinophora gossypiella; in Journ. Agr Res. 9, pp. 343—370.

17. — 1919. On some generic synonymy in the family Gelechiidae (Lep.); in Proc. Ent. Soc. Wash 21, 4, pp. 94—96.

18. Durrant, J. H. 1912. Notes on Tineina bred from Cotton Bolls; in Bull. Ent. Res. 3, 2, pp. 203—206.

19. Fletcher, T., Bainbrigge, 1917. Rep. Proc. Soc. Ent. Meeting Pusa, Feb. 1917, 10, pp. 111—114.

20. Hancock, G. L. R. 1927. Note on Species of Platyedra occurring in Uganda; in Proc. S. & E. Afr. Agric. Conf. 1926, pp. 228—229.

21. Heinrich, C. 1921. Some Lepidoptera likely to be confused with the Pink Bollworm; in Journ. Agr. Res. 20, 10, pp. 807—836.

22. Hill, G. 1924. Insects affecting cotton in Australia; in Proc. Pan Pacific Congr. 1923, pp. 406—408.

23. Holdaway, F. G. 1926. The Pink Bollworm of Queensland; in Bull. Ent. Res. 17, pp. 67—83.

24. Ingalls, A. G. 1926. The Great Earth Moon Catastrophe; in Sci. Am. 135, p. 109.

25. Marlatt, C. L. 1918. The origin of the Pink Bollworm; in Sci. 48, pp. 309—312.

26. Meyrick, E. 1895. Handbook of British Lepidoptera.

27. — 1918. Exotic Microlepidoptera, 2, p. 136.

28. — 1922. Results of Dr. E. Mjöberg's Swedish Scientific expedition to Australia 1910—1913. 27 Microlepidoptera; in Ark. Zool. Stockh. 14, No. 15, 13 pp.

29. — 1927. Exotic Microlepidoptera, 3, p. 351.

30. Pickering, W. H. 1907. The place of origin of the moon. — The volcanic problem; in Journ. of Geol. 15, pp. 23—38.

31. Pink Boll Worm; in Journ. Ec. Ent. 10, p. 225.

32. Rep. of Australasian Ass. for Ad. Sci. Meeting Perth; 1926.

33. Saunders, W. W. 1843. Descriptions of a Species of Moth destructive to the Cotton Crops of India; in Trans. Ent. Soc. London, 3, pp. 284—285.

34. Schuchert, C. 1924. The paleogeography of Permian time in relation to the geography of earlier and later periods; in Proc. Pan. Pac. Congr. Aust. 2, pp. 1079—1091.

35. Thornberg, D. H. 1925. Review of Wegener's "Origin of Continents and Oceans"; in Bull. Am. Ass. Petroleum Geologists, pp. 916—918.

36. Tillyard, R. J. 1926. The insects of Australia and New Zealand; Angus and Robertson, Australia.

37. Turner, A. J. 1919, in Proc. Roy. Soc. Q'land 31, p. 124.

38. Tryon, H. 1924. The genus Platyedra (Cotton Pink Bollworm genus) in Australia; in Proc. Pan. Pac. Congr. Aust. 1923, pp. 353—361.

39. Vosseler, J. 1904. Einige Feinde der Baumwoll-Kulturen in Deutsch Ostafrika; in Mitt. Biol. Landw. Inst. Amani, No. 18, p. 4.

40. Wegener, A. The Origin of Continents and Oceans; (Engl. Ed.) Methuen & Co., 1924.

41. Willcocks, F. C. 1916. The insects and related pests of Egypt, 1 (1): The Pink Bollworm, Cairo.

42. Van der Gracht and others, 1928. The Theory of Continental Drift: A symposium, 240 pp., 29 figs.; in Amer. Assoc. Petr. Geol., Tulsa, 1928.

Note Complémentaire sur les Coccides Monophléboides.

Dr. Paul Vayssière,
Directeur-Adjoint de la Station Centrale d'Entomologie, Paris.

(Avec 5 figures.)

En 1926, je tentais une revision des Coccides qu'on a coutume de grouper dans la sous-famille des *Monophlebinae*. Il me manquait certaines espèces américaines qui me furent aimablement communiquées ultérieurement par H. Morrison. Ce dernier a tout récemment publié un excellent mémoire sur la famille des "*Margarodidae*" (juillet 1928) pour laquelle il donne une classification très serrée en groupant les espèces dans des sous-familles, tribus et genres nombreux. J'avais cru pouvoir conserver pour

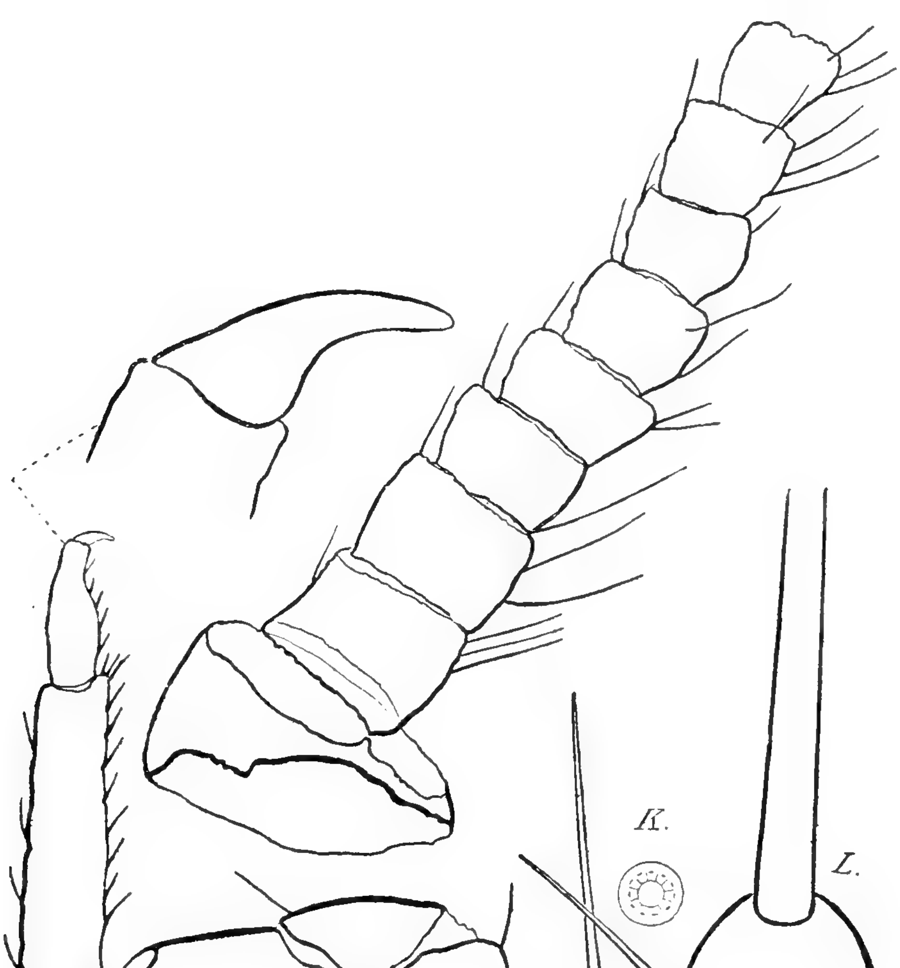


Fig. 1.

les *Monophlebinae* seize genres seulement; Morrison classe les mêmes espèces dans un nombre presque double de genres. Des tableaux dichotomiques sont également donnés. Malgré tout, il ne m'apparait pas sans

intérêt d'apporter ci-dessous les quelques observations que m'a suggéré l'étude de quelques espèces américaines qui appartiennent à la collection nationale des Etats-Unis.

1. *Protortonia primitiva* Towns. (fig. 1).

Dans son dernier travail *) Morrison reprend le genre *Protortonia* pour cette espèce à côté de laquelle il place le *Coccus cacti* de Linné. A l'excellente description donnée par l'entomologiste américain il n'y a que peu de mots à ajouter. Le tégument de la femelle adulte ne présente qu'un seul type de glande (K) ainsi qu'un seul type de soie (M) sans collerette. De très gros poils (L) se rencontrent sur le pourtour du corps, surtout à la partie postérieure. L'appareil buccal est absent sur l'échantillon communiqué.

Étude d'après une préparation microscopique No. 1878, in coll. Washington avec les indications: *Llaveia primitiva* on Nettle Tree, Morales Mex., Koebele coll. 31 mai 1897 175/12.

Cette espèce est étroitement alliée aux *Llaveia* tandis que son étude microscopique l'éloigne complètement du Coccide qui a été décrit par Newstead sous le nom de *primitiva* var. *pimentae* et que j'ai classé dans le genre *Crypticerya* (1926). Donc on doit séparer ces 2 espèces sous les noms de *Protortonia primitiva* et *Crypticerya pimentae*.

Enfin, il y a lieu de faire remarquer que Townsend n'attribuait que 9 articles aux antennes de *primitiva*. Des échantillons montés au baume de Canada par Koebele présentent en effet ce caractère parce que leurs antennes sont incomplètes, mais j'ai pu voir à Washington des exemplaires ayant bien leurs antennes de 11 articles.

De même l'appareil buccal existe sur un individu et le mentum présente nettement des poils sensoriels en spatule comme les *Llaveia*.

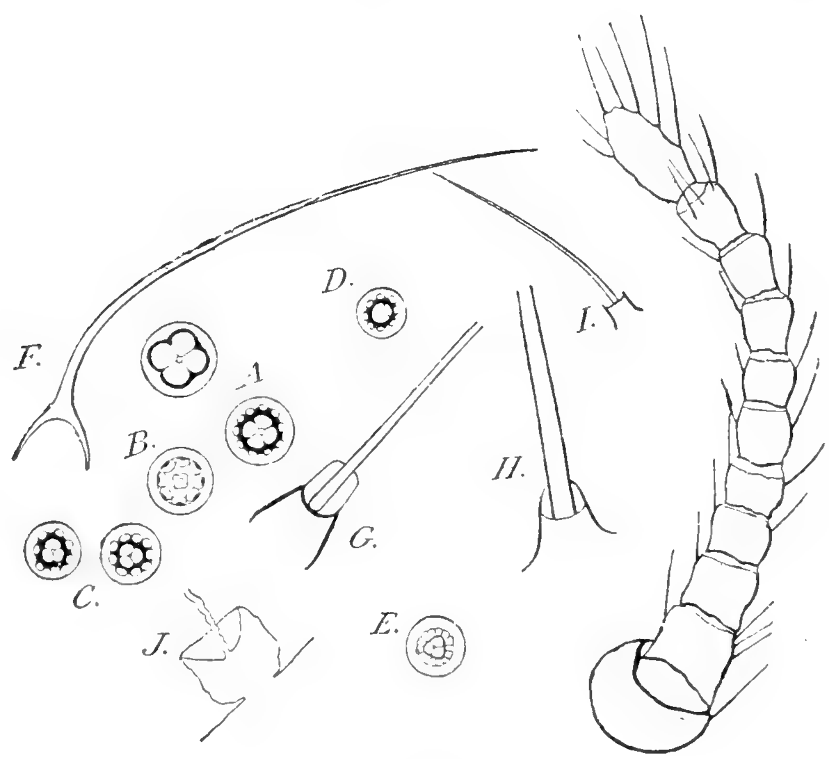


Fig. 2.

*) H. Morrison: A classification of the higher groups and genera of the Coccid family *Margarodidae;* in Techn. Bull. No. 52, U. S. Dept. Agric., Washington, 1928.

2. *Icerya schrottkyi* Hempel (fig. 2).

La substance cireuse qui recouvre la femelle est très blanche; elle se prolonge en arrière de l'insecte d'une longueur au moins égale à celle du corps de ce dernier. Des filaments bouclés surtout sur le pourtour du corps.

Caractères microscopiques. — Echantillon préparé: L = 6 mm, 1 = 5 mm Antennes de 11 articles: 11, 10 (2, 3, 6), (1, 8, 9), (4, 7), 5 (fig., 2). Les yeux sont bien dévelopés; le mentum n'est pas visible et aucune patte n'existe dans la préparation. Les stigmates thoraciques sont normaux, ceux de la 2ème paire environ double plus grands que ceux de la première. Les 3 paires de stigmates abdominaux, caractéristiques du genre *Icerya*, sont présentes (fig. 2, J).

L'area anale est garnie d'une vingtaine de grosses soies (H), avec quelques glandes multiloculaires (E). Ces mêmes glandes se retrouvent en abondance sur le tégument abdominal, tant de la face dorsale que de la face ventrale; mais elles paraissent moins chitinisées que le tégument qui les entoure.

A la face dorsale, dans la partie antérieure du corps, on trouve des poils (F) ainsi que des glandes multiloculaires de deux tailles différentes (B, D). L'une de celles-ci (B) se rencontre très abondamment sur tout le pourtour du corps où elle se mélange avec une autre grosse glande (A), à orifice central quadrioculaire entouré d'une dizaine de petits orifices, dont l'aspect varie nettement avec la mise au point. Avec ces glandes, des petites soies (I) et des soies (G) à grande collerette sont également autour du corps.

Enfin, il existe une bande secrétrice du sac ovigère, caractérisée par cinq rangées autour de l'abdomen d'une glande (C) à orifice central normalement trioculaires avec 7 à 10 perles relativement grosses sur le pourtour.

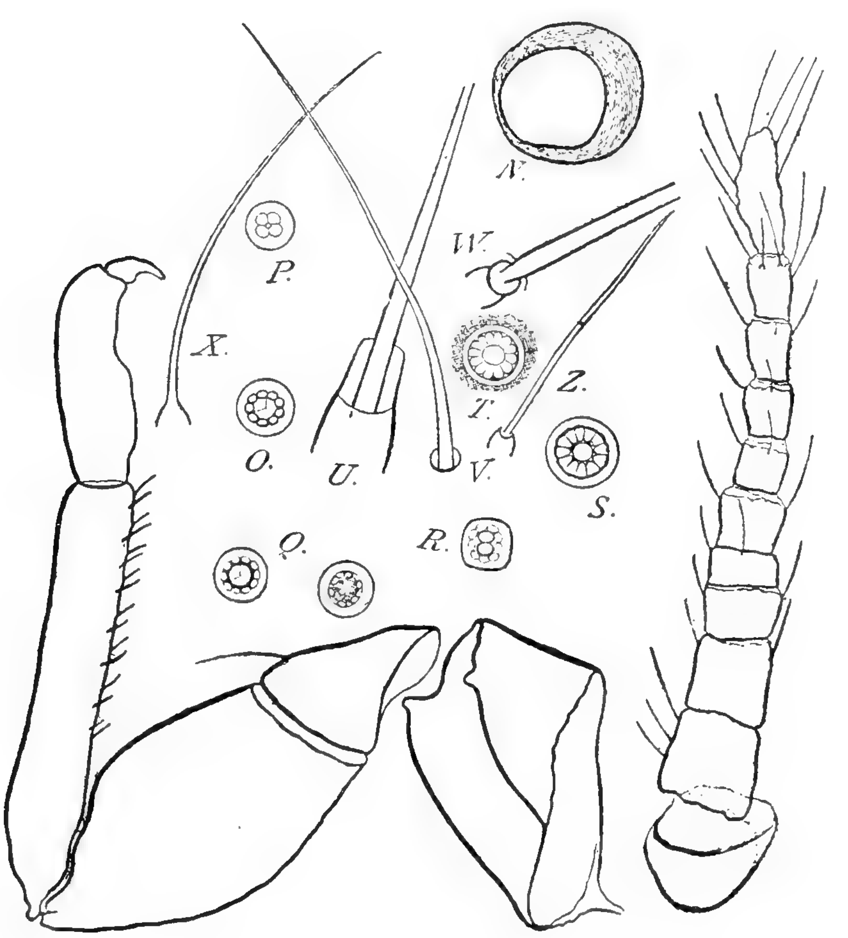


Fig. 3.

Étude microscopique d'après un échantillon, ex du type, in coll. E. E. G r e e n ; étude microscopique d'après préparation du type São Paulo 1900, in coll. Washington.

3. *Icerya zetecki* Cockerell (fig. 3).

Les caractères macroscopiques furent parfaitement bien donnés par C o c k e r e l l dans la description originale.

Caractères microscopiques. — Bien que le mentum soit visible sur la préparation, il n'a pas été possible de préciser la présence des poils en spatule. Les 3 paires de stigmates abdominaux existent (fig. 3).

Antenne de 11 articles: 11, 2, 3, 10, 6 (1, 7, 8, 9), 4, 5. Cette formule est sensiblement la même que celle donnée par C o c k e r e l l, toutefois 10, dans l'exemplaire étudié, est nettement plus long que (1, 7, 8, 9). Pattes robustes, la partie interne du tarse s'incurvant vers la moitié de la longueur.

L'orifice anal est d'un diamètre relativement grand; il est entouré par une large area chitinisée garnie d'une cinquantaine de poils robustes (W) et d'un nombre équivalent de glandes multiloculaires (T) enfoncées dans la chitine.

Sur la face ventrale de l'abdomen, on localise nettement la fente génitale par une zône très riche en glandes multiloculaires (S) un peu différentes des glandes précédentes (T) et en petits poils (Z).

La bande secrétrice de l'ovisac est essentiellement formée par des glandes (O) en général à orifice central trioculaire et entre cette bande et l'area génitale on trouve épars sur le mince tégument abdominal des glandes (R) à pourtour sensiblement quadrangulaires avec un orifice central biloculaire entouré d'une dizaine de perles.

Dorsalement à la partie antérieure du corps, le tégument est garni de soies à grande collerette (U) que l'on retrouve en petit nombre sur tout le pourtour du corps, de soies simples (V, X) et de glandes (O) multiloculaires.

Dans la région abdominale, sur la même face du corps, en dehors de l'area anale, les glandes multioculaires, quoique de même diamètre que celles de la partie antérieure, se présentent au microscope sous un aspect (Q) un peu différent.

Le tégument ventral, entre les antennes, est orné par un type de glande (P) relativement simple mélangé avec des soies simples (V, X) de longueurs diverses.

Enfin, il y a lieu de noter que l'échantillon étudié en préparation microscopique présentait épars sans symétrie de très nombreux ilôts irréguliers à cellules polygonales qui ne doivent correspondre qu'à des altérations locales du tégument.

Dans la description qu'il donne de cette espèce, C o c k e r e l l note la ressemblance extérieure qu'elle possède avec *L. brasiliensis* de H e m p e l.

La préparation de cette dernière espèce que j'ai eue, en 1926, entre les mains (coll. E. E. G r e e n) ne m'a pas permis d'en faire une étude aussi complète que pour *I. zetecki.* Toutefois, l'ensemble des éléments du derme étudié sur les exemplaires des 2 espèces me permet d'envisager, avec de très fortes présomptions, que l'avenir permettra sur du bon maté-

riel d'établir une identité entre elles: *zetecki* passant en synonymie de *brasiliensis*.

Étude microscopique d'après une préparation in coll. Washington portant les indications: Ancon C. Z., A. H. Jennings coll. 1910.

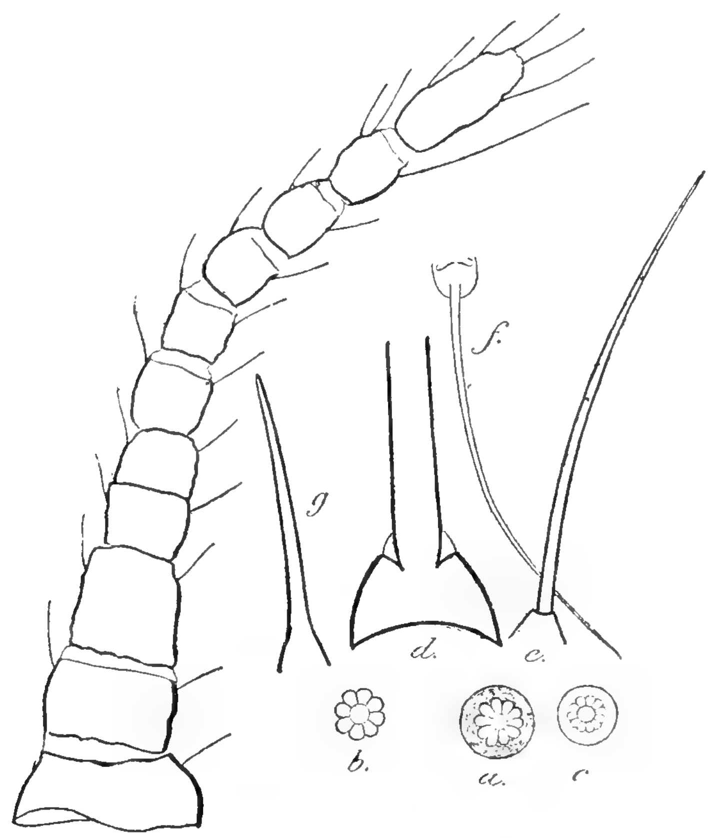


Fig. 4.

4. *Steatococcus mexicanus* Cockerell et Parrott (fig. 4).

Caractères microscopiques. — Antenne de 11 articles: 11, (2, 3), (6, 9, 10), (7, 8), (1, 4, 5). Une soie relativement très longue sur le dixième article. Trois paires de stigmates abdominaux, chacun de ceux-ci étant placé de chaque côté, dans un des derniers ilôts glandulaires dont la présence est signalée ci-dessous.

Sur le pourtour du corps, on compte en effet de chaque côté, dix ilôts composés d'une vingtaine de glandes à orifice multiloculaire en rosace ayant un pourtour assez fortement chitinisé. Entre ces ilôts, surtout des grosses soies (d) et d'autres plus petites (e), mais aucune de ces productions ne possède une collerette telle que je l'ai constatée chez d'autres *Steatococcus*.

Le tégument, tant dorsal que ventral, est garni d'une mélange de soies (d, e), d'épines (g). Entre ces ornements sont en rangées plus ou moins régulières des glandes multiloculaires (a) à pourtour chitinisé, ainsi que d'autres (b) également à rosace et de même taille, mais qui n'ont pas de pourtour épaissi. Enfin, sur la face ventrale de l'abdomen, le tégument est garni de glandes (c) en rosace un peu plus petites que celles du reste du tégument et moins chitinisées que celles-ci. De fines soies (f) sont entre ces glandes et surtout autour de la partie tégumentaire ornée par les glandes (c). Cette partie du corps correspond à la poche marsupiale particulièrement nette chez les autres espèces du même genre *) (*caudatus*, *gowdeyi*, *morrilli* ou *townsendi*).

*) Vu à Washington un individu ayant une poche marsupiale plus différenciée que chez l'insecte qui m'avait été précédemment communiqué à Paris.

Par l'ensemble de ses caractères microscopiques, cette espèce ne me parait pas étroitement alliée avec les *Steatococcus* que j'ai pu étudier. Il faudrait pouvoir approfondir son étude pour préciser sa place dans la classification des *Monophlebinae,* aucune coupe générique actuelle ne lui convenant d'une façon satisfaisante.

D'après un échantillon préparé, in coll. Washington, récolté sur Acacia, Aquas calientes, Mexique, E. A. Schwartz, coll. 12 février 1909.

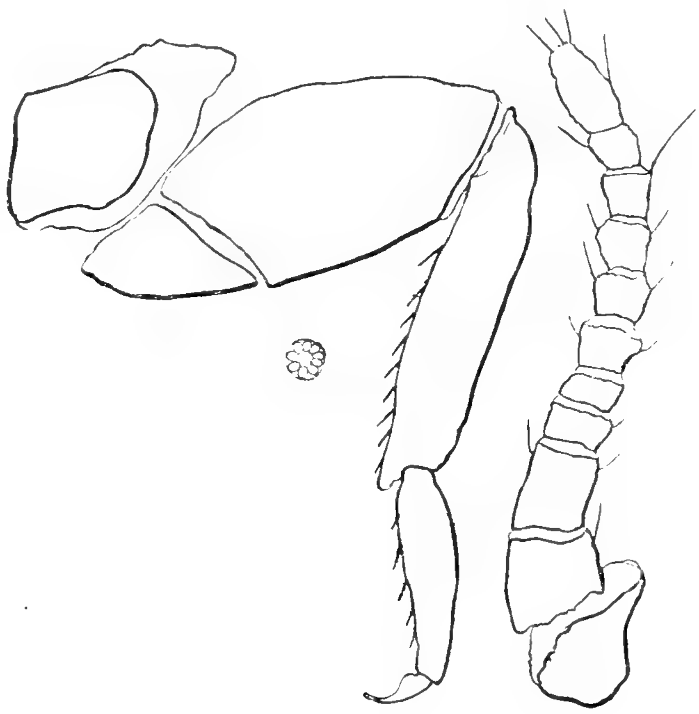


Fig. 5.

5. *Steatococcus townsendi* Cockerell (fig. 5).

J'ai pu, en 1926, fourni une description de cette espèce d'après un exemplaire existant en préparation au British Museum (Natural History), Je n'ajouterai aujourd'hui que quelques lignes devant accompagner des dessins représentant les appendices qui étaient absents sur l'échantillon conservé dans la collection anglaise.

Antenne: 11, (2, 3), 1, 6 (7, 8, 9), (4, 5, 10). Pattes robustes, avec crochet particulièrement bien développé.

Un seul type de glande épars sur tout le tégument, même sur le pourtour de la poche marsupiale, contrairement à la supposition que j'ai pu émettre dans ma précédente étude de cette espèce. Ma première opinion tenait à une différence de coloration des éléments figurés du derme due à leur situation dans une région plus ou moins chitinisée.

Exemplaire en préparation microscopique, in coll. Washington avec les indications: *Icerya townsendi* N. M. 7272, Oct. 96 (Townsend) 147/7.

De l'emploi du Cyanure de Calcium comme Insecticide en France.

Dr. Robert Regnier,
Directeur de la Station entomologique et du Muséum de Rouen.

Parmi les produits insecticides qui ont particulièrement retenu notre attention ces dernières années, nous avons à citer le cyanure de calcium, d'origine américaine, qui donne au simple contact de l'air un dégagement relativement lent d'acide cyanhydrique; la grande toxicité de ce gaz le rend très précieux pour la destruction de certains ravageurs, invertébrés et vertébrés.

Ce produit, livré en poudre ou granulé, suivant que l'on désire un dégagement plus ou moins rapide du gaz, est d'une manipulation très facile, et n'exige de l'expérimentateur que de la prudence dans son emploi, tant pour lui-même que pour les plantes à traiter, certains végétaux se montrant très sensibles à l'action de l'acide cyanhydrique. On s'en sert déjà dans un certain nombre de régions françaises pour la destruction des rongeurs et des insectes, mais jusqu'ici son utilisation est restée presque exclusivement réservée contre les Rats, contre des insectes nuisibles aux habitations, et pour le traitement des serres. Les résultats obtenus confirment d'une manière générale les recherches américaines: le produit s'est montré nettement efficace pour le traitement en espace clos contre tous ces ravageurs.

Nous avons voulu nous rendre compte s'il ne serait pas possible d'en étendre l'emploi contre certains insectes nuisibles à des cultures spécialisées et à des plantes de grande culture, soit par des poudrages, soit par des injections dans le sol, et nous sommes arrivés à des conclusions assez intéressantes, que nous allons exposer.

Nos expériences ont porté sur des insectes très différents et notamment sur des Hyménoptères sociaux, des chenilles fileuses, des Pucerons, des larves souterraines, et les Coléoptères nuisibles au Colza. Les résultats ont varié non seulement suivant l'état de développement de l'insecte, mais aussi suivant les circonstances d'emploi. D'une façon générale nous avons constaté la sensibilité des insectes parfaits, surtout des Hyménoptères et des Lépidoptères, et la grande résistance des chenilles et des larves des mêmes insectes.

Nous avons peu expérimenté sur les Diptères, mais comme pour les Hyménoptères, nous avons constaté la grande sensibilité des imagos; quant aux larves, elles sont d'autant plus difficiles à atteindre qu'elles vivent en milieu humide, et généralement elles se sont montrées résistantes.

Les Hémiptères, qu'il s'agisse d'Hétéroptères, de Cicadelles, de Pucerons ou de Cochenilles, paraissent insensibles au poudrage; nous ne les avons détruits qu'en opérant en espace clos, serre, tente ou cloche; pour les petites espèces vagabondes, la mort est généralement très rapide, et survient en 2 à 3 minutes, tandis qu'il ne faut pas moins de 10 minutes de contact pour tuer les espèces sédentaires ou fixes, comme les Pucerons et Cochenilles. Nous avons détruit en totalité des Pucerons lanigères *(Eriosoma lanigerum)* et des Pucerons verts *(Aphis mali)* sur de jeunes pommiers par ce procédé à des choses de 4 à 5 grammes par mètre cube, sans nuire à la végétation de la plante.

Les chenilles sont parmi les espèces les plus résistantes; nous ne parlons pas des pontes des Lépidoptères, sur lesquelles le cyanure s'est montré sans action, même avec un contact prolongé dans des conditions pratiques. Nous avons vu de jeunes chenilles de *Pieris brassicae* résister pendant plus de 15 minutes à des concentrations de 25 grammes par mètre cube, dose beaucoup trop forte pour la plupart des végétaux. Quant aux chenilles fileuses *(Hyponomeuta)* contre lesquelles nous avions essayé des poudrages sous bâche, elles ont également toujours résisté; sur les toiles de contrôle que nous placions au-dessous, nous trouvions des papillons, des mouches, des ichneumons, mais jamais de chenilles; quant aux chenilles qui se trouvaient protégées par le réseau soyeux, elles continuaient à manger, comme si rien n'avait été fait. Nous n'avons obtenu de résultats que dans nos destructions de Teignes des tapisseries et de la cire, en laissant les objets à désinfecter, enfermés pendant plusieurs heures dans des récipients hermétiques, en contact avec du cyanure de calcium à la dose de 25 à 50 grammes par mètre cube. Ici même, nous considérons ce produit comme un procédé de choix, et déjà plusieurs maisons en France en font une utilisation importante.

Le cyanure de calcium n'est pas moins précieux pour la destruction des Hyménoptères sociaux; la sensibilité des Guêpes et des Abeilles est telle qu'il est possible de les tuer en plein vol avec une seule insufflation; les Fourmis offrent une plus grande résistance: il ne faut pas moins de 2 minutes de contact pour les immobiliser en période sèche. Pour détruire les colonies de Guêpes, Frelons *(Vespa)*, Abeilles importunes, mauvaises Ruches, nids de Fourmis, il suffit d'insuffler ou même simplement de déposer dans le trou d'entrée quelques grammes de cyanure de calcium; toute la colonie se trouve détruite, sans qu'on ait d'autre précaution à prendre que celle de boucher le trou aussitôt après l'injection du produit.

Contre les larves souterraines, la plupart très résistantes aux meilleurs insecticides, l'efficacité est en fonction de plusieurs facteurs: la résistance propre et la mobilité de l'individu, la nature du sol et son degré d'humidité. Les sols sablonneux retiennent moins le gaz que les sols argileux, si donc la larve est très mobile, comme c'est le cas des larves de Taupins *(wireworms)*, elle échappe facilement à l'action du cyanure, dont le dégagement d'acide cyanhydrique devient relativement raide; on ne pare à cet inconvénient qu'en tassant la terre par un roulage préalable, et en multipliant les injections dans le sol, mais alors l'opération devient assez dispendieuse. En terrain meuble, nous n'avons pas obtenu une mortalité supérieure à 20%, alors que nous sommes arrivés à 80% en terre argileuse. D'autre part il est à noter que l'évaporation du produit est beaucoup plus rapide (près du

double) en période humide qu'en période sèche, on a donc avantage à choisir pour l'application une période de beau temps, et, si l'on opère dans des couches, à éviter d'arroser le jour de l'application.

Les larves mélolonthoïdes et curculioniformes d'une façon générale paraissent moins sensibles que les larves élatériformes; nous avons vu des larves de Cétonides résister pendant 8 jours aussi bien en terrain argileux qu'en terrain sablonneux, alors que dans le même temps nous obtenions, comme nous venons de l'indiquer, 80% de mortalité des larves de Taupins en sol argileux, et 20% en sol sablonneux.

Ces variations dans les résultats montrent la nécessité pour les auteurs des rapports scientifiques de préciser les conditions dans lesquelles l'expérience a été poursuivie.

Pour les Coléoptères nos essais ont porté surtout sur de petites espèces nuisibles aux Crucifères (Chou, Colza) et au Pois: *Meligethes*, *Ceutorrhynchus*, *Sitona*, et Altises. Les *Meligethes*, dont une espèce, *M. aeneus*, est très nuisible au Colza en Seine-Inférieure, sont les plus sensibles: avec un simple poudrage, ils sont tués en moins de 30 secondes; les Altises et les Charançons sont plus résistants, il ne faut pas moins d'une minute et demie à deux minutes de contact pour les tuer, et comme au moindre danger ces insectes ont l'habitude de se laisser tomber, beaucoup sortent de la nappe de gaz et échappent ainsi au traitement.

Nous avons précisé dans des notes précédentes, présentées à la Société des Amis des Sciences naturelles de Rouen*), les détails de plusieurs de nos expériences. Nous nous bornerons à souligner ici les résultats obtenus: avec les *Meligethes*, nous avons atteint 100% de mortalité, alors qu'avec les Altises et les Charançons, nous avons difficilement dépassé 70%.

Pour opérer, il suffit d'avoir une bonne poudreuse, d'employer le produit en poudre par temps sec de préférence et de marcher le vent dans le dos, pour éviter d'être gêné par les émanations du gaz. L'importance chaque jour plus grande de la culture spéciale du Colza, par suite de l'utilisation des graines comme huile végétale industrielle et comme huile de table, montre l'intérêt de ces recherches. Il est à souhaiter que, pour en généraliser l'emploi, le prix du cyanure de calcium puisse être abaissé très sensiblement, car actuellement l'opération est dispendieuse en grande culture et réservée aux traitements spécialisés.

---

*) R. Regnier. De l'utilisation du cyanure de calcium en poudrage dans la lutte contre certains insectes nuisibles: Bull. Soc. Amis Sc. Nat. Rouen, 3 Nov. 1927.

The Pink Bollworm (Platyedra gossypiella Saunders) in the Sudan.

H. H. King, Government Entomologist, Sudan.

INTRODUCTION.

Pink bollworm is believed to have been introduced into the Sudan in cotton-seed imported from Egypt prior to 1915, in which year the importation of cotton-seed from that country, except under special permit, was prohibited. Egypt in turn is thought to have received the pest from India, from which country it was recorded in 1843. It was first noticed in Egypt in 1910 and in the following year had apparently become well established there, but its potentialities as a serious pest were not recognised until 1913. Its occurrence in the Sudan was first noted in April 1916, in seed from the Tokar crop, and in the following season it was found in bolls from Kassala, Fung, Khartoum and Berber Provinces. Its present distribution in the Sudan probably embraces every district in which cotton is grown. In some districts it occasions very serious loss, in others it is responsible for relatively little damage, while in certain localities, such as Tokar, it cannot even be considered a pest.

CONDITIONS UNDER WHICH COTTON IS GROWN.

Cotton, of both American and Egytian types, is mainly a winter crop, sowing taking place usually from July to September, depending on local conditions. The methods under which it is grown varies with the different ways in which the crop receives its water and may be considered under three heads, viz. a) Sakia, pump and freeflow irrigation, b) flood irrigation and c) rain.

a) Sakia, pump and freeflow irrigation. — The Sakia is the primitive wooden waterwheel worked by cattle, which has been used by natives of the Nile Valley from time immemorial for raising water from the river for irrigation purposes. The majority of the pumps used for lifting river water to the land are owned and worked by Europeans. The completion of the Sennar Dam on the Blue Nile has resulted in the bringing of large areas under freeflow irrigation. The system of cultivation in all cases is essentially the same, in that the crop receives regular and controlled waterings throughout the season.

b) Flood irrigation. — In some localities, notably at Tokar and at Kassala, cotton is grown on land flooded by rivers which come down in heavy spate for a short period each year and spread out over deltas; for the remainder of the year these river are dry. Similarly, low-lying areas on the banks of the Nile which are either flooded naturally or by means of high level canals, functioning while the river is in flood, may be sown

to cotton. Under these conditions the crop normally received no water after being sown, except at Tokar and other places on the Red Sea littoral where light winter rains occur.

c) Rain. — In certain areas, which towards the South are very extensive, sufficient rain falls to permit of cotton being grown without other water supply.

LIFE HISTORY AND FOOD-PLANTS.

Nothing in the life history of *P. gossypiella* in the Sudan calls for special mention. The majority of the full-fed larvae at the close of the cotton growing season pass into the resting stage, and the moths which later result from these resting larvae are responsible for the infestation of the following season's crop.

Pink bollworm has not, up to the present, been found attacking any plant in the Sudan other than cotton.

PINK BOLLWORM AT THE END OF THE COTTON GROWING SEASON.

When the last picking of cotton has been taken from an infested crop, *P. gossypiella* in its various stages will be in the following situations: —

a) Eggs on the cotton plants.
b) Immature larvae in green bolls on the cotton plants.
c) Mature short cycle larvae and pupae in bolls attached to the cotton plants or lying on the ground, among debris on the ground and in the surface three inches of soil.
d) Moths among debris on the ground, in cracks in the soil, in buildings used as stores for seed-cotton and seed, and similar places.
e) Resting larvae in dry, unopened or partially opened bolls (which, owing to damage by bollworm or other causes, have yielded little or no lint worth picking), attached to the plants or lying on the ground, in seed fallen to the ground, in bolls and seed fallen into cracks in the soil, in bolls and seed taken to their burrows by rats, and in seed-cotton and cotton-seed in store.

Up to the present no resting larvae have been found free in the soil, though the pupae of short cycle larvae have been found recovered from the soil up to ten days from the cutting out of the old cotton plants. Our observations indicate that under Sudan conditions the average life of a *P. gossypiella* moth is considerably less than a month and that consequently, if the new crop is not sown until a month after the old cotton plants have been destroyed, the chances of moths from short cycle larvae living to oviposit on the new crop are extremely small. As regards resting larvae contained in fallen bolls, they have little chance, because, when the cotton plants are cut out and burnt, these bolls are left exposed to the fierce heat of the summer sun.

CONTROL MEASURES.

The control measures practised against pink bollworm all have as their object the eradication during the period elapsing between the cotton

growing seasons of *P. gossypiella* in all its stages. These control measures are as follows:

a) The destruction of the cotton plants after the last picking has been taken.

b) The observance of a "dead season" for cotton of not less than a month between the destruction of the plants of the old crop and the sowing of the succeeding crop.

c) The "sunning" of all seed required for sowing.

d) The export from the district of all seed cotton and seed by the beginning of the dead season.

a) The destruction of the cotton plants after the last picking has been taken. — The removal, for fuel or other purposes, of cotton sticks from the land on which the crop was grown, is prohibited. As soon as the last picking has been taken, the land is grazed over by sheep and goats which devour the leaves and green bolls and much of the seed-cotton which has fallen to the ground. The plants are then cut down, collected into heaps and burnt. — The date by which the destruction of cotton plants must be completed is fixed year by year for each district.

b) The observance of a dead season for cotton. — The date by which the old crop must be destroyed is fixed with a view to ensuring that a period of at least a month during which there is no cotton growing in the district shall elapse before the new crop is sown. In most districts the dead season extends for nearly two months, and in the case of flood- and rain-cotton even longer.

c) The "sunning" of all seed required for sowing. — "Sunning" is the method adopted for the destruction of resting larvae contained in seed, and consists of exposing the seed in a thin layer to the direct rays of the sun on a hot or moderately hot day. The seed is usually spread on palm leaf mats, spreading being started early in the morning and completed by 10 a. m. at the least. The temperature of the seed is taken at hourly intervals by heaping together a small quantity of the seed and pushing the bulb of a thermometer into the centre of the heap. The larva of *P. gossypiella* cannot withstand a temperature of 50^0 C for an hour; the minimum temperature accepted when sunning is 60^0 C for two successive hours, and in practice the seed is usually heated to 65^0 C or over. When the temperature of the seed has been maintained at 60^0 C or over for two hours, it is resacked. — The sunning of all seed required for sowing throughout the country is carried out under the direct supervision of officials of the Entomological Service. A man can supervise the treatment of rather more than 300 sacks (of 220 lbs.) a day.

d) The export from the district of all seed-cotton and seed by the beginning of the dead season. — This is probably the most important of the control measures and is certainly the most difficult to enforce. The bulk of the crop of seed-cotton is sent to ginning factories and exported, but very considerable quantities, and particularly from the last picking, are retained by natives for hand spinning and weaving and for the stuffing of mattresses, pillows, etc. Further, seed-cotten before being sent to the ginning factories is picked over and any which is dirty or stained removed; this refuse seed-cotton is frequently left in a corner of the hut or stuffed into the eaves of the thatch on the chance

that it may be of use later on. If the crop has been infested with pink bollworm, the later pickings, and to a certain extent the debris from the earlier pickings, will contain resting larvae, and, if retained within the district in unscreened stores, will constitute a major source of infestation to the succeeding crop. As proof of this, the following figures may be quoted. Last year, in a district, in which there had been a serious outbreak of pink bollworm, a total of 86,000 lbs. of seed (of which 34,000 were contained in seed-cotton) was obtained from the natives during the dead season. Representative samples (totalling 383 lbs.) of this seed were examined, and the results indicated that there was an average of 4.9 living larvae in each pound of seed. — Further proof of the importance of this control measure is furnished by the relative infestation of the cotton crop at Tokar, on the Red Sea littoral, and that grown in the Nile Valley. At Tokar the climate during the summer months is so objectionable that as soon as the crop has been picked and the cotton sticks cut and burnt the natives leave the district for the hills, to return later in time to sow the succeeding crop; any cotton retained by them is taken out of the district. Although *P. gossypiella* was at one time well established there, it is only at the end of the season and as a result of careful search that an occasional specimen may now be found. In the Nile Valley, on the other hand, where the villages are in close proximity to the cultivations and where considerable quantities of native handwoven cotton cloth is produced, pink bollworm remains a major pest, in spite of the fact that the seed used for sowing is sunned and at the end of the season the cotton plants are cut and burnt as at Tokar.

BIOLOGICAL CONTROL.

Two species of hymenopterous parasites of the pink bollworm are indigenous to the Sudan — *Microbracon brevicornis* and *M. kirkpatricki.* The former has a relatively wide range of hosts, including the Sudan or red bollworm *(Diparopsis castanea),* the Egyptian or spiny bollworm *(Earias insulana)* and the Dura stemborer *(Sesamia cretica),* and is readily bred under laboratory conditions. The female, however, possesses but a short ovipositor, and it is doubtful whether she is capable of stinging and ovipositing on a pink bollworm unless it is near the surface of the boll. *M. kirkpatricki* has up to the present been found attacking only pink bollworm and is less easy to breed in captivity. The female has a longer ovipositor and appears capable of reaching a larva anywhere in the boll. — Although both these parasites may be relatively plentiful at the end of the cotton growing season, their numbers become reduced to the minimum during the hot dry summer months when they — and in particular *M. kirkpatricki* — must have great difficulty in finding larvae on which to oviposit. The possibility of breeding them in the laboratory during the summer for release early in the cotton growing season is being studied.

The Status of the Cotton Leaf Worm (Alabama argillacea Hbn.) in the West Indies.

H. A. Ballou, Commissioner of Agriculture for the British West Indies, Trinidad.

The present cotton growing industry in the West Indies dates from about 1902, when the first estate trials were made in growing Sea Island cotton in the Leeward Islands. In 1904 a general planting campaign with selected seed received from South Carolina was undertaken, and from that time on cotton growing has formed an important part of the agricultural industry in several of the West Indian Islands. In St. Vincent and Montserrat it is the principal crop grown, and for several years in Nevis it was the principal crop. In St. Kitts and in Barbados it has been entirely secondary to sugar-cane, and in Antigua it has been grown to some extent.

In 1903 the cotton worm appeared in great numbers, and did a considerable amount of damage in several of the islands, and in every year since then it has appeared in sufficient force to be counted a pest in one or another of the islands. With the exception of the island of St. Vincent, all the cotton growing islands have experienced these cotton worm attacks in nearly every cotton season.

The history of cotton worm attacks in St. Vincent is rather remarkable. For several years after the cotton worm was recognized as a regularly recurring pest in other islands, the insect did not occur in St. Vincent in sufficient numbers to attract attention. In several seasons slight attacks on very limited areas were observed, but these attacks were controlled by the natural enemies of the cotton worm without the use of insecticides. Such attacks were mostly confined to the south-eastern portion of the island, and these sporadic occurrences sometimes extended in a westerly direction across the southern part of the island. In 1926, however, the cotton growers of St. Vincent experienced the first general attack of cotton worm over the whole cotton growing area. That year, it may be mentioned, was a bad cotton worm year in all the West Indian Islands. The losses in St. Vincent were severe. The planters had failed to realize the necessity of maintaining their store of insecticides and in response to calls from other islands had shipped away practically all the arsenicals that had formerly been held in stock.

We have never been able to obtain any record of the cotton worm living over from one cotton season to another in any of these islands. Specimens have been taken at light as early as June, and from June on to December and January the caterpillars have been recorded at work in the cotton fields. I am of opinion that *Alabama argillacea* invades these islands each year, the invaders being stragglers from the swarms which

migrate from South America to the cotton belt of the Southern States. Our West Indian form, *Aletia luridula*, appears to be indigenous, occurring on cultivated cotton and perhaps on some wild plants. This species very rarely occurs in sufficient numbers to attract attention, but on occasions has been the principal insect attacking cotton in some of the islands.

Slight invasions of *Alabama* are promptly controlled by natural enemies, and this has been particularly noticeable in St. Vincent, where these natural enemies have been particularly abundant. The natural enemies include both predaceous and parasitic insects. The eggs of *Alabama* are parasitized by *Trichogramma* and *Telenomus*. A Chalcid (*Chalcis* sp.) has frequently been bred from the pupa, and a Sarcophagid fly has also been obtained in considerable numbers from pupae under conditions which make it seem certain that this insect is also parasitic.

Our common wasps of the genus *Polistes* are very efficient predators. These insects have been particularly abundant in St. Vincent, and I have been inclined to believe that they were very important in the control of the early attacks of the cotton worm in that island. Unfortunately, *Polistes* appears to be dying out in some of the islands as a result of the attacks of a small moth which invades the nests.

Paris green and London purple are the insecticides which have been chiefly used for the control of the cotton worm in the West Indies in the past. Within the last two or three years trials have been made of calcium arsenate, and it appears likely that this insecticide will be used more in the future. Application has been made generally by the use of cloth bags, the insecticides being applied in the form of dust, usually mixed with air-slaked lime at the rate of 1 to 6 by weight. In cases where the bags have been made of a suitable material and the application has been properly supervised, this method has been satisfactory, both from the point of view of economy and that of efficiency. Careless methods have resulted in wastage, injury to the plants, and failure to control the pest. Carelessness in observing the attack in the early stages has also been responsible for loss in the cotton crop. Blower dusters of the Savage and Niagara type and several bellows dusters have been under trial in the last few years, and there is a probability that the use of these machines will be increased.

The success of the cotton industry of these small islands has been due to the fact that it has been a community interest. Each island is so small that it has been possible to arrange fairly definite planting dates, and for many years now, each island has declared a close season during which no old cotton is allowed to be standing in the fields and all cotton plants and scattered bolls, seed-cotton, etc., are required to be cleaned up and burnt. The close season usually occupies a period from 1 to 2 months, after which planting may begin for the next crop. Since the appearance of the pink bollworm in these islands, the close season has been very rigidly enforced. The close season was originally intended to control the cotton pests and diseases generally. In St. Vincent, however, it has had specific reference to the control of the cotton stainers, and in all the islands since 1920 it has, of course, also been definitely directed to the control of the pink bollworm.

There would be no difficulty in controlling cotton worm by the methods which have been used, and with the arsenicals which have been

employed, if it were not for the effect of frequent heavy showers during the growing season of the cotton. In some seasons the planter is compelled to repeat his dusting daily over the several days during which a brood of cotton worm is feeding. No trials have been made of aeroplane dusting in these islands, as it has been felt that with the small areas to be treated the cost would be prohibitive.

The length of the life cycle of the cotton worm in these islands appears to be about the same as in the Southern States during the summer months. No swarming from the northward flight has been observed, but it seems probable that at the end of the season these insects obey the impulse common to the species to migrate, and probably this migration is to the North.

The present Status of the Fruit Fly Problem in Mexico.

Dr. Alfons Dampf, Chief Entomologist, Oficina Federal para la Defensa Agricola of the Mexican Department of Agriculture, Mexico City.

I have the pleasure to attend the Congress as a special representative of the new Mexican Plant Protection Service, which has authorized me to give a short account of the present status of the Fruit Fly Problem in Mexico, one of the problems to which we have recently paid particular attention.

As you all probably know, the Mexican fruit fly is very different from the Mediterranean fruit fly *(Ceratitis capitata)*, which has now spread nearly around the world and has hampered, in a unprecendented manner, international fruit trade. Mexico is till now fortunately free from this dangerous pest, but has in its place various species of the genus *Anastrepha (ludens, striata, fratercula, serpentina, acidusa*, etc.), which attack a great variety of fruits, and the presence of which has provoked a quarantine by the United States, absolutely prohibiting the entry of citrus and other fruit from Mexico into their country.

The fruit fly as a pest has been known in Mexico more than seventy years and has frequently been studied by Mexican and American entomologists, as for instance by Rangel, Alfonso L. Herrera, de la Barreda, Isaac, Crawford, Mann and others, but no one has attempted to produce a monographic work, based on an exhaustive study, like the admirable one published in the United States on the Rocky Mountain Locust, or like the monographs on the boll weevil, and the pink bollworm, or the last studies on the corn borer. The only paper which brings together all the existing knowledge and adds a number of new facts, is Dr. Crawford's publication, which appeared in 1918—1921 in Spanish in a Mexican agricultural review (Revista Agricola, Vol. II, Nr. 11, 1. of August 1918, Mexico City, pp. 458—462, and Vol. III, Nr. 1/9, 1921, pp. 174—199) and afterwards in English (in the Monthly Bulletin of the Californian Department of Agriculture, 1927, pp. 422—455). The Spanish text was republished with slight corrections in the Bulletin of the present Mexican Plant Protection Service (Boletin Mensual Oficina Federal para la Defensa Agricola).

The introduction of *Anastrepha ludens* into the State of Texas last year changed the situation completely. The Bureau of Entomology of the United States and the Federal Horticultural Board understood immediately the danger to the fruit-growing Southern States and started a campaign which forever will remain one of the most interesting experiments in applied entomology. I mean the introduction of a host-free period by removing all fruit from the trees for a period of at least six months in

the infested area. The next year will show if the calculations of the experts have been correct.

But the more important consequence of the invasion of the fruit fly to American territory is this: the Bureau of Entomology in Washington decided to start a thorough scientific investigation of the Mexican insect and to send a commission to its native country with the purpose to organise there a laboratory with modern equipment and with a staff of trained men. Dr. A. C. Baker of said Bureau, in charge of tropical and subtropical plant insects, began in February of this year to negotiate with the Mexican Department of Agriculture in regard to the site of the proposed laboratory, and I can say that this idea found the most enthusiastic welcome in our country. The Secretary of Agriculture ordered immediately, by special order of the President of Mexico, General Plutarco Elias Calles, the renovation of the buildings where formerly the laboratories of the Veterinary College of Mexico City had been located, and put the whole plant at the disposition of the American commission. I am glad to say that the repair work is finished and that the laboratories very soon will start their work under the supervision of Dr. Chester I. Bliss, formerly in charge of the Bureau of Entomology laboratories in New Orleans, who is especially trained in physiological work.

As early as March of this year the American commission established at Cuernavaca in the State of Morelos, known for a long time as the chief center of *Anastrepha* infestations, an insectary, where Mr. McPhail and Mr. Molino are conducting breeding experiments. The whole research work follows a very thorough and detailed program, prepared by Dr. Bliss, which, I hope, will be published soon. As far as I know, Mr. McPhail is preparing a paper giving the first results of the Cuernavaca studies.

As to the Mexican Government, we not only tried to help the American commission with buildings and with personnel to procure material and to assist in the border eradication work, but it was also decided that the Mexican Office of Plant Protection Service should take an active part in the research work. I will outline to you in a few words what program will be followed and regret much not to be able to present to you the fruits of our collaboration, which will be available only in the forthcoming years.

The first problem, and a basic one, is the problem of taxonomy. We must clear up how many species are involved in the fruit fly problem, how they are distributed over the Mexican territory, and we must not only try to distinguish the adult forms, but also the immature stages, the larvae and pupae. This necessitates a thorough study of the whole morphology of all stages, as we have to conduct a biometrical analysis of the accessible external organs and parts, to prove the existence or non-existence of geographical and physiological races and as we can not rely on the characters used in our present dipterology, but must find new ones.

These studies have been started in the laboratory of the Mexican Plant Protection Service and we have ordered all our inspectors, distributed over the country, to supply the necessary wormy fruits. We hope in this way to get sufficient material to come to an understanding of the taxonomy of the genus *Anastrepha* in respect to the Mexican species. It would

be interesting to find out, if there are, as in *Glossina*, the famous Tsetse fly, also fly free zones and fly belts, and to study the reasons. There are, for instance, places in Mexico where the infestation is very heavy, 50—60%, as in Cuernavaca in mangoes, and others where the infestation is negligible, one tenth or a hundreth %, as in some citrus groves on the Gulf Coast. The solution of this problem, which obviously depends on ecological factors, will be tried by the Bureau of Entomology, and this program includes among other things a study of the soil fauna in the Mexican fruit groves, in order to get an idea about the influence of ants and other subterranean insects on the pupae in the soil and on the maggots, which have to leave the fallen fruits and must search for a pupating place. This will be, as far as I can see, the first attempt to study the tropical soil fauna from an ecological, or better a biocoenotic, standpoint.

The Laboratory of the Mexican Government is also charged with the preparation of a complete study of the embryonic development and of the internal anatomy of the larvae and the adult, which data are indispensable for the successful conducting of the physiological investigations. So intimate is the collaboration between the two Governments that this part will be executed in the laboratories of the American Commission by the scientist commissioned by the Mexican Government.

I hope that this short exposée will show you that the solution of the Fruit Fly Problem, a problem common to both countries, is being attempted in a really harmonious and international manner by the Governments of Mexico and the United States.

Some Observations on the so-called European Corn Borer in Japan*).

Professor Satoru Kuwayama, Sapporo, Japan.

The so-called European corn borer (*Pyrausta nubilalis* Hübn.), as in Europe and in North America, has been one of the most serious pests destructive to Italian millet (*Setaria italica*) and Indian corn (*Zea mais*) in Japan for a long time, and it is also known to attack hemp (*Cannabis sativa*), Chinese indigo (*Polygonum tinctorium*), hop (*Humulus lupulus*), kidney bean (*Phaseolus vulgaris*), adzuki bean (*Phaseolus angularis*), sugar beet (*Beta vulgaris* var. *rapacea*), and many other plants. This pest is widely distributed in Japan, through Hokkaido, Honshu (Hondo), Shikoku, Kyushu and Chosen (Corea), while it is not reported from Karafuto (Saghalien), Okinawa (Loo-choo) and Taiwan (Formosa).

The publications of various authors with regard to this insect in Japan are not few in number, but many of them are inaccessible to workers who do not read Japanese. The author also worked on this pest in Hokkaido, the northern part of the Empire, since 1922, mostly on the lines of ecology and controlling methods. The present paper is intended to report on some ecological studies and controlling methods of this insect carried out in Japan.

Formerly this insect was usually referred to in Japan as *Botys lupulinalis* Hufnagel and sometimes as *Spilodes kodzukalis* Holland, which are undoubtedly synonyms of *Pyrausta nubilalis* Hübner. By Matsumura (17)**) the name of *P. nubilalis* was first applied to this species in 1905, and then that name has been used by our entomologists. On the other hand, Dyar (11) presented another name, *Pyrausta polygoni*, for the Japanese specimens which were reared from the Chinese indigo (*Polygonum tinctorium*). On closer comparison of the larvae found in the corn stems at Sapporo with those on the Chinese indigo in the Province of Awa, both under natural conditions, the author is able to state on the morphological characters that there is no specific difference between these larvae. Indeed, Caffrey and Worthley (10) stated in 1927 that "Dyar differentiated his species from *nubilalis* on several characters, chief among which was the similar coloring of males and females, which character would indeed exclude it as a synonym of *nubilalis*". They also added the opinion of Heinrich as follows: "Its genitalia are identical with *nubilalis* and on that account Mr. Heinrich is of the opinion that *polygoni*, with some reservation, should be considered a synonym of *nu-*

*) This paper is based on work done at the Hokkaido Agricultural Experiment Station and is published with the approval of the Director.

**) Numbers in paranthese refer to the Bibliography at the end of the paper.

bilalis". The author's opinion above stated is in accord with that of Caffrey and Worthley.

Before proceeding further, the author wishes to express his gratitude to Prof. Dr. S. Ito and other members of the station staff for their valuable assistance and help. He also wishes to express his warm thanks to Prof. Dr. S. Matsumura for much information regarding the insect dealt with in this paper, and also to Dr. L. O. Howard for his kindness in revising this paper.

Host Plants and the Adaptation to the Condition of the Flora.

In Japan, though the records of host plants are not yet so numerous as in the United States (Caffrey and Worthley [10]) or in Canada (Marshall [16]), we can enumerate at present about 30 species of various plants as the hosts of this insect, and these are tabulated in the following list:

Table I. A list of the host plants of *P. nubilalis* in Japan.

Names of host plants	Observers and reporters	Extent of injury at present
Gramineae		
1. *Phragmites communis* Trin.	Tanaka (24).	Slight in the Provinces of Owari (Nagoya) and Hizen (Nagasaki).
2 *Zea mais* L. (Indian corn)	Kuwana (13), Kuwayama (14), Matsumura (18), Murata (19), Okamoto (21), Takahashi (23), Tanaka (24), Niigata A. E. S. (5), Tokushima A. E. S. (9).	Most severe throughout Japan.
3. *Andropogon sorghum* L. (Great millet, Sorghum)	Kuwana (13), Takahashi (23), Tanaka (24).	Moderate; sometimes severe in certain localities of Japan.
4. *Eriochloa villosa* Kunth.	Tanaka (24).	Slight in the Provinces of Owari and Hizen.
5. *Paspalum thunbergi* Kunth.	Tanaka (24).	do.
6a. *Panicum crus-galli* L. var. *frumentaceum* Hack. (Japanese barnyard millet)	Kuwana (13), Kuwayama (14), Matsumura (18), Takahashi (23).	Moderate in some localities of Japan.
6b. *Panicum crus-galli* L. var. *hispidulum* Hack.	Tanaka (24).	Slight in the Provinces of Owari and Hizen.
7. *Panicum miliaceum* L. (Millet)	Kuwayama (14). Murata (19). Okamoto (21), Tanaka (24), Kagawa A. E. S. (3).	Severe in some localities of Japan.
8. *Beckmannia erucaeformis* Host.	Tanaka (24).	Moderate in the Provinces of Owari and Hizen.

Names of host plants	Observers and reporters	Extent of injury at present
9a. *Setaria italica* Beauv. (Italian millet)	Kuwana (13), Kuwayama (14), Matsumura (18), Murata (19), Okamoto (21), Onuki (22),	
9b. *Setaria italica* Beauv. var. *germanicum* Trin. (German millet)	Takahashi (23), Tanaka (24), Kagawa A E. S. (3), Niigata A. E. S. (5), Shimane A. E. S (6), Tokushima A. E. S. (9).	Most severe throughout Japan.
10. *Saccharum officinarum* L. (Sugar cane)	Kuwana (13).	Slight.
Zingiberaceae		
11. *Zingiber officinale* Roscoe (Common ginger)	Takahashi (23), Shizuoka A. E. S. (7).	Severe in the Provinces of Totomi and Suruga.
12. *Zingiber mioga* Roscoe	Takahashi (23).	Slight in Honshu.
Moraceae		
13 *Humulus lupulus* L. (Common hop)	Kuwayama (14), Murata (19).	Severe in the vicinity of Sapporo. Moderate in the Province of Shinano.
14. *Cannabis sativa* L. (Hemp)	Onuki (22), Takahashi (23), Niigata A. E. S. (5), Tochigi A. E. S. (8), Chosen A. E. S. (1), Kuwayama.	Moderate, sometimes severe, throughout Japan.
Polygonaceae		
15. *Polygonum nodosum* Pers.	Nawa (20).	Slight in Honshu.
16. *Polygonum blumei* Meisn.	Nawa (20), Tanaka (24).	Slight in the middle part of Honshu and the vicinity of Nagasaki, Kyushu.
17. *Polygonum tinctorium* Lour. (Chinese indigo)	Takahashi (23), Kuwana (13), Matsumura (18), Nawa (20), Onuki (22), Takahashi (23), Kagawa A. E. S. (3), Tokushima A. E. S. (9).	Severe in Shikoku and the southern part of Honshu.
18. *Polygonum thunbergi* Sieb. et Zucc.	Takahashi (23).	Slight in Honshu.
Chenopodiaceae		
19. *Beta vulgaris* L. var. *rapacea* Koch (Sugar beet)	Kuwayama (14, 15).	Moderate in Hokkaido, especially in the Provinces of Ishikari and Tokachi.
Leguminosae		
20. *Glycine hispida* Maxim. (Soybean)	Kuwayama 14), Nawa (20).	Slight in Hokkaido and Honshu.
21. *Phaseolus angularis* Wight (Adzuki bean)	Iguchi (12), Kuwayama (14), Nawa (20), Kagawa A. E. S. (3).	Moderate, sometimes severe in the Provinces of Oshima (Hokkaido), Mino, Settsu (Honshu), and Sanuki (Shikoku).

Names of host plants	Observers and reporters	Extent of injury at present
22. *Phaseolus vulgaris* L. (Kidney bean)	Kuwayama (14), Tokushima A. E. S. (9).	Severe in the Province of Shiribeshi. Moderate or slight in Hokkaido, excluding Shiribeshi, and in the Province of Awa (Shikoku).
Solanaceae		
23. *Solanum melongena* L. (Egg plant)	Kuwayama.	Slight in the Province Ishikari, Hokkaido.
Compositae		
24. *Callistephes chinensis* Nees (China aster)	Kuwayama.	Slight. Observed only in feeding experiments.
25. *Dahlia variabilis* Desf.	Kuwayama (14).	Slight in the Province of Teshio, Hokkaido.
26. *Cosmos bipinnatus* Cav.	Kuwayama.	Slight. Observed only in feeding experiments.
27. *Petasites japonicus* Miq.	Takahashi (23).	Slight in Honshu.
28. *Chrysanthemum sinense* Sabin.	Kuwayama.	Slight in Hokkaido

As is seen from this table, though the corn borer has quite a good many host plants, the degree of its likes and dislikes differs naturally between the kind of them; furthermore this fact is influenced by several conditions. We have some practical examples. In Hokkaido, the primary host plants in the Province of Ishikari are Italian millet, Indian corn and hops, secondarily sugar beet and hemp, while millet and kidney bean are less affected and adzuki bean has not been attacked. In the Province of Shiribeshi kidney bean is the primary host and is severely affected, and secondarily Indian corn or millet. Further, in the Province of Oshima adzuki bean and Indian corn are most susceptible to the pest, but the other plants are not so much affected. In Honshu and Shikoku, the records of the primary host plants differ widely between the provinces as follows:

In the Province of Rikuchu . . . . Italian millet
In the Province of Shimotsuke . . . . hemp
In the Province of Echigo . . Italian millet, Indian corn and hemp
In the Province of Totomi and Suruga . . . . . common ginger
In the Province of Mino . . Chinese indigo, soybean and adzuki bean
In the Province of Harima . . . . adzuki bean
In the Province of Awa . Chinese indigo, Kidney bean and Indian corn
In the Province of Sanuki Chinese indigo, adzuki bean and wild Polygonum
In Chosen (Keiki-do) . . . hemp, Italian millet and Indian corn.

On comparison of the primary host plants in our country with those of foreign countries, we can find out more conspicuous differences between them. The severe injuries to Indian corn and hemp are similar throughout Japan, Europe, the United States or Canada, while oats, barley, Dahlia

and Zinnia, which are known to be severely or frequently attacked by the corn borer in the United States and in Canada, are not recorded as being affected or are only rarely attacked in Japan, some of the plants not being accepted by the insect in the feeding experiments carried out by the author. On the other land, the common hop and Italian millet which are severely infested plants both in Japan and Europe are only known to be attacked occasionally in the United States or in Canada. The sugar-beet is known to be severely or moderately infested by the corn borer both in Japan and Canada, but Caffrey and Worthley (10) classified it with the group of plants rarely attacked. The kidney bean is frequently attacked in the United States and in some localities of Japan, but in Canada it is known as an immune plant. These local variations of the primary host plants prove that the corn borer can easily accommodate itself to the local flora on account of its polyphagous habit. Accordingly, the decrease or increase of the cultivated areas of some crops in certain localities lead often to a sudden outbreak, or to a change in the primary host plants of the corn borer. For example, in the Province of Shiribeshi, Hokkaido, a slight injury on kidney bean done by the corn borer was found in 1917, but prior to this year the borer was known to be injurious only to Indian corn, Italian millet and other larger cereals. In 1918, the injury to kidney beans increased more and more, and during the next few years the extensive infestation of that crop continued. It is reported, however, that in 1923 millet was severely attacked by this borer in that section, with a corresponding reduction of injury to kidney beans. This phenomenon is connected with the change of the conditions of the local flora.

Table II. Areal percentages of two kinds of crops in the Province of Shiribeshi, Hokkaido.

Year	Areal percentages to the total cultivated land (field)		Remarks
	Larger cereals *	Kidney bean	
	%	%	
1911	6.9	8.2	
1912	9.0	12.2	
1913	10.6	13.2	
1914	10.4	13.9	
1915	9.4	13.2	
1916	8.8	14.9	
1917	7.4	20.1	Slight injury to kidney bean was first noticed in this year.
1918	6.5	20.5	The injury to kidney bean was severe.
1919	6.7	16.9	do.
1920	7.8	9.6	do.
1921	7.6	11.5	do.
1922	6.4	10.6	do.
1923	6.5	11.0	Millet was infested severely. The injury to kidney bean was reduced.
1924	6.8	12.2	
1925	6.9	11.7	

*) Larger cereals mean Italian millet, Japanese barnyard millet, millet, Indian corn and great millet.

From the above table we can easily recognize that the artificial transformation of the local flora, or the areal fluctuation of the host plants, is one of the most influential environmental factors in the alteration of the primary host plants of the corn borer in certain localities. The fact of the adaptibility of the corn borer to the various host plants is one of the most noticeable ecological characters of this insect, and stimulates further research.

Seasonal History and the Adaptation to Climatic Conditions.

According to the localities where the climatic complexes differ, there is a variation in the number of annual generations of the European corn borer from one to three. A variation of the seasonal history would naturally be expected in such a widely dispersed insect as the corn borer. The following table gives a partial list of the local variation in the number of generations. The data have been taken from miscellaneous sources of information and represent only generalized conditions.

Table III.

State	Province	Locality	Number of generations	Remarks
Hokkaido	Ishikari	Sapporo	1	A partial second generation during favorable seasons.
Honshu	Shinano	Nagano	1	Frequently a partial second generation during favorable seasons.
,,	Rikuchu	Morioka	2	
,,	Shimotsuke	Utsunomiya	2	
,,	Echigo	Nagaoka	2	
Chosen	Keiki-do	Suigen	2	Two complete generations and a partial third generation are reported.
Honshu	Owari	Nagoya	3	
,,	Izumo	Imaichi	3	
Shikoku	Awa	Tokushima	3	
,,	Sanuki	Takamatsu	3	

Though the factors that determine the number of generations have been discussed by many workers of foreign countries, yet the conclusions are far from complete; the solution of this problem should be approached from various angles. At present two stimuli of biological development are considered most important, one of which is the possibility of the existence of some distinct biological species, and the other is some climatic condition. In the United States, the difference in the number of generations, one and two between Western New York and Eastern Massachusetts, where the climatic complex is superficially the same, is considered to be evidence of the existence of two distinct biological species in these areas. No such fact has been observed in any locality of Japan. However, during his researches on climatic factors, especially temperature and precipitation, in various infested localities of Japan, the author found some data which are helpful in forecasting the number of generations in certain localities. The following

Tabl. IV. — Mean temperature and total precipitation in various infested localities of Japan.

Locality	Number of generations (A partial generation inclusive)	Mean temperature (C)		Total precipitation (mm)		Remarks
		Year	Half-year (May-October)	Year	Half-year (May-October)	
		0	0	mm	mm	
Sapporo . .	1 (2)	6.9	15.2	1092.6	538.8	49 years average (1877—1925)
Nagano . . .	1 (2)	11.0	19.0	1000.8	662.8	33 years average (1891—1923)
Morioka . .	2	12.3	20.9	1355.4	864.9	2 years average (1922 and 1925)
Utsunomiya	2	12.1	19.5	1592.6	1170.6	25 years average (1888—1912)
Nagaoka . .	2	12.6	20.3	2765.0	975.4	7 years average (1899—1905)
Suigen . . .	2 (3)	11.5	20.8	1118.4	884.3	16 years average (1909—1924)
Nagoya . . .	3	14.5	21.7	1766.2	1206.2	26 years average (1887—1912)
Imaichi . . .	2	15.8	22.9	1740.8	924.8	14 years average (1909—1922)
Tokushima	3	15.2	21.9	1806.8	1306.8	24 years average (1889—1912)
Takamatsu .	3	16.6	23.7	1176.6	831.0	10 years average (1916—1925)

table gives the data of climatic factors in the above mentioned localities which have been taken from miscellaneous sources of meteorological surveys.

According to the preceding table the yearly mean temperatures in the one-generation localities is below 11.5° C, and that in the three-generations localities is over 14.5° C, that in the two-generations localities being between them. The mean temperatures from May to October, which are considered as the active time of the corn borer, are in accord with those of the years, that is to say, they are below 19.0° C in the one-generation localities, from 19.0° C to 21.0° C in the two-generations localities, and over 21.0° C in the three-generations localities. It is easily recognized that both yearly and half-yearly total precipitations in the localities having more generations are more plentiful than those of the localities which have fewer generations.

To verify these facts obtained in Japan, the following data are tabulated from various sources in foreign countries.

In this table the mean temperature in Europe is not more than 11.0° C in the one-generation localities and from 12.0° C to 15.0° C in the two-generation localities on yearly averages, or below 19.0° C in the one-generation localities and over about 19.0° C in the two-generations localities, and this tendency clearly conforms with that of Japan. But the relation to total precipitation does not so distinctly confirm the observations made in Japan. The mean temperature in the infested localities of North America seem to be quite different from those in Japan, while the precipitation in the two-generations localities surpasses that of the one-generation localities, which bears some similarity to our conditions. From the data

obtained in our investigation we may forecast the number of generations in a locality on the whole as follows:

Table V. — Mean temperature and total precipitation in various infested localities of foreign countries.

Locality	Country and State	Number of generation (A partial generation inclusive)	Mean temperature (C)		Total precipilation (mm)	
			Year	Half-year (May-October)	Year	Half-year (May-October)
(Asia)						
Koshurei	South Manchuria . .	1	6.7	19.1	618.0	564.2
(Europe)						
Paris	Northern France . .	1	10.6	15.5	536.2	295.4
Odessa	Ukraine fSouth-Western Russia)	1 (2)	9.9	18.3	317.9	232.1
Budapest	Hungary	1	10.0	16.9	617.0	274.4
Marseille	Southern France . .	2	14.3	18.9	588.3	281.6
Tiflis	Transcaucasia	2	12.1	19.8	514.2	345.2
Milan	Northern Italy	2	12.5	20.0	1175.0	602.4
(North America)						
New York . . .	New York, U.S.A. .	1 (2)	11.1	19.0	1076.9	549.8
Albany	New York, U.S.A. .	1 (2)	8.1	16.7	704.0	471.7
Center County	Pennsylvania, U.S.A.	1 (2)	9.8	16.8	862.4	471.8
Wooster	Ohio, U.S.A.	1 (2)	9.7	17.7	999.3	546.1
East Lansing .	Michigan, U,S.A. . .	1 (2)	8.2	16.9	791.1	449.0
Toronto	Ontario, Canada . .	1 (2)	7.9	16.5	767.2	362.4
Orono	Maine, U.S.A.	2	6.0	14.9	1041.8	497.1
Durham	New Hampshire, U.S.A.	2	7.2	15.7	1158.7	532.2
Kingston	Rhode Island, U.S.A.	2	8.7	16.2	1520.6	598.4
Storrs	Connecticut, U.S.A.	2	8.2	16.1	1215.7	605.6

Table VI. — Climatic ranges between the localities which produce one to three generations of *P. nubilalis*.

Range / Mean atemperature and precipitation	Range in one-generation-localities	Intermediate range	Range in two-generations-localities	Intermediate range	Range in three-generations-localities
Yearly average of mean temperature	below 11.5° C	11.0°-12,0° C	11.5°-14.5° C	14.0°-15.0° C	over 14.5° C
Half-yearly average of do. (May-October)	below 18.5° C	18.0°-19.0° C	18.5°-21.0° C	?	over 21.0° C
Precipitation . . .	lesser	—	medium	—	more

The data given are only preliminary, since the experimental results have not as yet been all completely checked. All the climatic factors, not only temperature and precipitation, must be studied in order to obtain the solution of the physiological problems of the corn borer. It is not our purpose in this paper to review the work of other entomologists on these

problems, nor shall we attempt to compare the records of our own experiments with those of any other worker. The author has not only called attention to this apparently remarkable correlation between the development of the corn borer and climatic factors, but also has shown that some factors are determinants of development, as far as the scientific points have as yet been elucidated The foregoing studies draw attention to important points which deserve the most careful and thorough investigation.

Some Experiments on the controlling Methods.

As Caffrey and Worthley (10) have already stated, from the fact that the insect passes the greater part of its larval and pupal stage within the host plant, thus affording but little chance for insecticidal or other remedial measures on a large scale, it is evident that the major control efforts should be directed towards cultural practice leading to the destruction of infested plants or sheltered objects. In the case of Indian corn, the corn borer hibernates always in the infested stems of the host plant, and therefore it is necessary to utilize these as fodder of livestock or to destroy the infested plants by burning or plowing under. When the corn borer attacks kidney bean, the full-grown larvae often bore into the stem of the bamboo-grass (*Sasa paniculata)* as overwintering place in the fall time, since the farmers in Hokkaido are in the habit of using bamboo-grass as the poles of bean. When the bamboo-grass is fresh, the larvae only bore into the upper cut end, but after two or three years' use they can bore into the bamboo-grass through every internode. Taking cognizance of these facts, experiments on the treatment of bamboo-grass poles were carried on by our Experiment Station staff during the spring seasons of 1922 and 1923, namely immersion of the bamboo-grass poles in running water during 24 or 48 hours, or in boiling water for 5, 15, 30 and 60 minutes, or fumigation with carbon-bisulphide at the rates of 3, 5, 10 and 20 pounds per 1000 cubic shaku,*) for 24 oder 48 hours. Of these experiments the boiling water immersions for over 5 minutes proved always the most effective, while the immersion in running water was ineffective. We see from the experimental results, that the fumigation of bamboo-grass poles with carbon-bisulphide must be at least at a rate of 10 pounds per 1000 cubic shaku and for more than 24 hours. When fresh bamboo-grass is used as poles of kidney bean, its upper end must be cut off at the node, since the corn borer easily bores into the bamboo-grass through the hole in the top.

Bibliography.**)

1. Anonymous: — A General Summary of the Experimental Results of the Agricultural Experiment Station, Government-General of Chosen. (Reference on pp. 106—107). 1925.
2. Anonymous: — Control of the Noxious Insects: "Rinjihokoku" (Special Bulletin) No. 13 of the Iwate Agr. Exp. Sta. Reference on pp. 25—26. 1909.
3. Anonymous: — "Ai-no-meichiu" (Chinese indigo borer): Special Report No. 2 of the Kagawa Agr. Exp. Sta. pp. 17—29 pl. II. 1904.

*) shaku=0.99421 foot.

**) All are written in Japanese, excluding the articles marked with an asterisk*, which are written in English.

4. Anonymous: — Preventive Measures as to enemies of Crops: Publication of the Nagano Agr. Exp. Sta. Reference on pp. 11—12. 1916.
5. Anonymous: — Report of the Experimental Results; No. 19 of the Niagata Agr. Exp. Sta. 181 pp. Reference on pp. 3—6, 17, 20. 1907.
6. Anonymous: — Annual Report for the year 1923 of the Schimane Agr. Exp. Sta. 218 pp. Reference on p. 170. 1924.
7. Anonymous: — "Shoga-no-meichiu" (Common ginger borer): Report of the Experiments on Noxious Insects; No. 1 of the Schizuoka Agr. Exp. Sta. pp. 15—17, Pl. VI. 1905.
8. Anonymous: — Ecological Observations on "Asa-meichiu" (Hemp borer): Annual Report for the year 1924 of the Tochigi Agr. Exp. Sta. pp. 258—266. 1925.
9. Anonymous: — Investigations of the Insect Pests of Chinese Indigo: Publication of the Tokushima Agr. Exp. Sta. 33 pp. Reference on pp. 9—10. 1922.
*10. Caffrey, D. J. & Worthley, L. H.: — A Progress Report on the Investigations of the European Corn Borer; in U. S. Dept. Agr., Bull. No. 1476. 154 pp. 1927.
*11. Dyar, H. G.: — A Descriptive List of a Collection of Early Stages of Japanese Lepidoptera; in Proc. U. S. Nat. Mus., Vol. 28, No. 1412, pp. 937—956. 1905.
12. Iguchi, S.: — On "Ki-sazanami-usuba" (Serious Pest); in "Konchu-Sekai" (Insect World), Vol. 10, No. 111, pp. 461—462. 1926.
13. Kuwana, I.: — Manual of Agricultural Entomology. Reference on pp. 186—187. 1918.
14. Kuwayama, S.: — A List of the Insects injurious to Agricultural and Horticultural Plants in Hokkaido; in Bull. No. 42 of the Hokkaido Agr. Exp. Sta. Reference on p. 54. 1926.
15. Kuwayama, S., Kuribayashi, K. and Oshima, K.: — Insect Pests and Fungus Diseases of Sugar Beet, with Special Reference to Controlling Methods; in Bull. No. 36 of the Hokkaido Agr. Exp. Sta. Pls. I—III Reference on pp. 36—40. 1925.
*16. Marshall, J.: — The Occurrence of the European Corn Borer in Ontario in Plants other than Corn and its significance; in 57th Ann. Report of the Ent. Soc. of Ontario for 1926, pp. 28—32. 1927.
17. Matsumura, S.: — Catalogus Insectorum Japonicorum. I (Rhopalocera et Heterocera). Reference on p. 219. 1905.
18. Matsumura, S.: — Applied Entomology. I. Reference on pp. 534—535. 1917.
19. Murata, J.: — Manual of Fungicides and Insecticides. Revised 3rd Ed.: Publication of the Nagano Agr. Exp. St. Reference on p. 158. 1922.
20. Nawa, U.: — On the Controlling Methods of China Indigo Borer: "Konchu-Sekai", Vol. 9, No. 96, pp. 315—317. 1905.
21. Okamoto, H.: — Life-histories of Injurious and Beneficial Insects in Hokkaido: Report No. 12 of the Hokkaido Agr. Exp. Sta. Reference on pp. 12—16. 1921.
22. Onuki, S.: — Economic Entomology. Reference on pp. 192—193. 1903.
23. Takahashi, S.: — Text-book of Agricultural Entomology. Reference on pp. 173, 175, 217, 221, 233, 329 and 341. 1923.
24. Tanaka, K.: — Studies on the Pyralids which attack the Gramineous Plants in Japan. Part I: "Byochu-gai-Zassi" (Journ. of Plant Protect.), Vol. 15, pp. 288—295., I Pl. 1928.
*25. Thompson, W. R. & Parker, H. L.: — The European Corn Borer and its Controlling Factors in Europe; in U. S. Dept. Agr. Techn. Bull. No. 59. 62 pp. 1928.
*26. Thompson, W. R. & Parker, H. L.: — Host Selection in *Pyrausta nubilalis* Hübn.; in Bull. Ent. Res., Vol. XVIII, Pt. 4, pp. 359—364. 1928.

The Mass Production of Trichogramma minutum Riley and Observations on the Natural and Artificial Parasitism of the Codling Moth Egg.

S. E. Flanders, Entomologist,
Saticoy Walnut Growers Association, Saticoy, California.

(With 13 text-figures.)

Introduction.

The goal of biological control work is generally considered to be the restoration of the "balance of nature", that equilibrium between the noxious phytophagous insect and its enemies which will maintain injury to the food plant below the economic minimum. This has already been accomplished in many well known instances by the introduction and establishment of the parasites and predators of introduced pests. Incomplete ecologic adaptation may be counteracted through artificial propagation as in the case of *Cryptolaemus montrouzieri* Muls., which is under a seasonal handicap in its relation to its host, the citrophilous mealybug.

Further developments in biological control look toward the inclination of the balance to parasite superiority. This may be accomplished by the mass production method or the artificial propagation and periodic release of large quantities of a native parasite, such as the small chalcid *Trichogramma minutum.*

Character of Trichogramma.

Forty-six-years ago Riley made the observation that egg parasites, since they kill their victim before it has begun to do any damage, are among the most efficient destroyers of insects injurious to vegetation. Of the vast numbers in which these tiny parasites occasionally appear but few persons are aware. At that time, as in the present day, the last brood of the cotton worm was sometimes "almost annihilated" by *Trichogramma.* Hinds and Spencer report that it is the most effective natural control of the sugar cane borer in Louisiana.

The little chalcid is cosmopolitan in distribution and has a wide range of diverse habitats and hosts. In several instances it has been introduced into isolated localities. The first introduction occurred in 1911, when de Bussey introduced it into Sumatra to serve in the control of *Heliothis obsoleta* Fab. on tobacco. The sticky surface of the young tobacco leaves, however, prevents effective parasitism. *Trichogramma minutum* was probably indigenous, attacking hosts not under investigation.

The hosts of this parasite, according to Martin, number well over one hundred and fifty species in the orders Lepidoptera, Coleoptera, Hymenoptera, Neuroptera, Diptera and Hemiptera. It has been known to

attempt oviposition in the juice globules of okra plants, the swollen abdomen of the mite *Pediculoides* sp., and in paper smeared with the hair-covering of the egg-masses of the browntail moth. The majority of its hosts, however, are lepidopterous, and its oviposition is confined to eggs deposited on exposed surfaces and without a protective covering of a hard, hairy or sticky substance. A hymenopterous host, however, is recorded as having the highest number of individuals developing in a single egg. In Wisconsin thirty pupae were found in an egg of *Cimbex americana.*

Albert Koebele seems to have been the first to record it as a parasite of the codling moth. In 1889, at the time he made his epochal introduction of *Rodolia cardinalis* Muls. into California, he found many codling moth eggs parasitized by *Trichogramma.*

Under natural conditions its appearance in abundance is seasonal and irregular. This is mainly due, as Radetsky observed, to insufficient hosts in which to winter.

Organized production as a means of overcoming this handicap captured the imagination of entomologists in Europe, and the early experimentation in the biological control of the codling moth was performed by them.

Adaptability to Biological Control Work.

Trichogramma minutum is adapted for this work in many ways. Some of the biotic responses that determine its adaptability are as follows:

1. It mates and oviposits readily in confinement;
2. develops to maturity in the eggs of grain moths, 1 individual per host egg ;
3. has a shorter life-cycle than any host (under outdoor conditions less than one-third that of the codling moth);
4. has a more extended developmental range than its hosts (the threshold of development is about 10 degrees lower than that of the codling moth) ;
5. has a great variety of hosts and, according to Dr. Hase, no host preference ;
6. accommodates itself as to number of generations according to host it parasitizes, as ascertained by Dr. Marchal;
7. develops throughout the year, temperature and food permitting ;
8. has few competing species and no secondary parasites;
9. dispersal is so localized that its effectiveness is measurable;
10. and this effectivenes is determined by its abundance on the food plant of the host and by the amount of host material within its sphere of action.

Factors that limit to some extent its adaptability are as follows:

1. It does not appear to be specific as to host location (apparently finds host by means of random movements, tending to climb upward and fly downward);
2. Under natural conditions when in the host egg is prey to such predators as ants, lady-bird beetles and mites (a 10% mortality due to predators may be expected).

When more than one parasite develops within an egg, the first to emerge forms an opening through which predaceous mites find entry.

Early Methods of Increasing Parasite Population.

In 1916 Mokrzecki and Bragina in Russia stated that theoretically "an unlimited number of *Trichogramma* may be reared in the laboratory". Three years earlier Mokrzecki had found it necessary to caution the fruit growers against exaggerated expectation in the artificial production of this parasite. The objective in this early work was the acceleration of natural reproduction. The earliest method of laboratory host production was that used by Pospelow, who reared larvae from the winter imagos of *Euxoa segetum* on sprouted wheat and slices of potato. Later Portchinsky suggested collecting large quantities of overwintering larvae or pupae of a prolific host of *Trichogramma,* forcing their early maturity and oviposition, and parasitizing their eggs with *Trichogramma* carried over for the purpose from the preceding season. He advocated the use of *Phalera bucephala* L., since the overwintering pupae could be purchased for one mark per dozen.

Later it was found that the eggs of *Ephestia kuehniella* Zell. were suitable for the reproduction of *Trichogramma* and were more readily obtained. In Japan *Ephestia* has been used recently to produce *Trichogramma* for use against the rice moth. The susceptibility of *Ephestia* to larval parasitism and the webbing habit of the larva tended to limit its use in quantity production.

Another method suggested by Vuillet and also by Harland was that of increasing the abundance of hosts on the windward side of infested plantings. For example, *Mamestra brassicae* was suggested as a preliminary host adjacent to a vineyard infested with *Polychrosis botrana.*

A similar situation occurred naturally in Southern California in 1926 when the codling moth was found to be heavily parasitized as early as the middle of May. The butterfly, *Vanessa cardui,* had occurred in great numbers during March and April and had deposited quantities of eggs everywhere. It appears probable that this butterfly served as a preliminary host to *Trichogramma.* Whatever the preliminary host, on one walnut tree two hundred out of three hundred codling moth eggs were found to be parasitized prior to the 25th of May.

Cultural practices such as the burning of sugar cane trash and the flooding of cranberry bogs appear to reduce the abundance of *Trichogramma* the following spring. Experiments in the maintenance of *Trichogramma* in the sugar cane fields of Louisiana through the conservation of cane trash have been conducted during the last ten years, but positive data on its hibernation in cane trash is lacking. Clean cultivation by reducing the number and variety of the food plants of the hosts of *Trichogramma* acts as a check on the abundance of the latter. In Southern California there is a noticeable difference betweeen the degree of parasitism of the codling moth in orchards and on fruit trees in dooryard situations where food plants of moths are present throughout the year.

Initiation of Mass Production.

In 1925 Harry S. Smith had suggested to the writer that *Trichogramma minutum* was the most adaptable egg parasite with which to attempt the biological control of the codling moth, since it "is well adapted

to this purpose and breeds with extreme rapidity". Consequently when its natural effectiveness was manifested so strikingly in 1926, the possibility of using it in control work was given serious consideration.

The failure of other workers to accomplish results indicated that success could only be attained by the low cost production of great quantities of *Trichogramma*, so that it could be made effective in the field through sheer force of numbers.

With this idea in mind, experimentation began August 11th, 1926. Ten females reared from *Tortrix* eggs secured in the field were allowed to oviposit in the eggs of *Ephestia kuehniella.* Subsequent generations were reared on the lichen moth, *Illice nexa* Boisd., and the potato tuber moth, *Pthorimaea operculella* Zell. The fifth generation was reared on *Sitotroga cerealella* Oliv., which was selected for further experimentation, because it was available in large numbers and had the convenient habit of ovipositing in narrow crevices, forming an egg mass of one layer. As the writer was the first to use this moth as a laboratory host, he was enabled to solve the problem of the mass production of *Trichogramma.*

During October about a million silk-worm eggs were donated by the American Silk Factors, Inc., at San Diego for testing as a laboratory host of *Trichogramma.* Although the silk worm egg proved to be attractive, the tough chorion prevented oviposition. Ten females were observed on one egg, each drilling vigorously in an effort to oviposit. It is doubtful if large eggs will prove to have any advantage in artificial production over an equal number of small eggs other than higher production per egg. Under laboratory conditions the host egg would be heavily parasitized and the parasites produced would probably be as small as those from eggs such as *Sitotroga.* This condition occurs in the field when more than three parasites develop in a codling moth egg. The azygous pupa or the one occurring singly may be twice the length of the smallest of the zygous pupae.

Adaptability of Sitotroga.

Sitotroga cerealella proved to be peculiarly adapted to the quantity production of *Trichogramma.* Countless generations can be reared from stored grain under regulated conditions, the tropisms of the adults are such as to simplify their accumulation into egg deposition cages and their oviposition responses facilitate the collection of eggs. It has relatively few enemies; bacterial and fungoid diseases are rare. In common with other insects it suffers from the ravages of the mite *Pediculoides ventricosus* Newport. A large mite, *Tyroglyphus* sp., feeds to some extent on the eggs, the flat grain beetle, *Cryptolestes pusillus* Schönh., will attack the newly hatched larva, and *Dibrachys boucheanus* Ratzeburg, is recorded as parasitising the pupae. *Pediculoides,* however, was the only one of these to interfere with our production.

Under laboratory conditions the life-cycle of *Sitotroga* is about 28 days, and its fecundity about 40 eggs per female. This correlation permits a high rate of reproduction. The habits and tropisms of *Sitotroga* and their value in the mechanical manipulation of production are as follows:

The feeding and the pupal stages occur within the kernels of grain, so that the interspaces are not clogged with frass and webbing. The

newly emerged moths, therefore, have free egress from the deeper layers of grain. Incidentally this grain has a higher sales value after using than grain matted with webbing and excreta.

The newly emerged moths are flexible in their movements as are the larvae, and at first are negatively geotropic and thigmotropic, so that they all issue from compactly arranged tilted bins. The moths mate promptly after emergence and their pre-oviposition period is less than 24 hours under laboratory conditions. Maximum oviposition occurs within 60 hours after emergence, so that the moths can be handled in crowded egg deposition cages, wherein the adult life is shortened to two or three days.

During the daytime moths tend to crawl upward and come to rest in positions of positive thigmotropism and negative phototropism. Loose boards resting against vertical surfaces serve as "trap-nests".

Crevices about $^{23}/_{100}$ of a mm or one hundredth of an inch in width stimulate egg deposition. By crowding the bottoms of the egg cages with moths their bodies form crevices that stimulate egg deposition, and the constant shifting causes the eggs to drop through the 20-mesh screen into a trough below. It is interesting to note that *Sitotroga* will oviposit through a 20-mesh screen into a strong current of air from an electric fan. The air current stimulates oviposition.

Development of Rearing Methods.

The development of rearing methods progressed rapidly, because of these habits and tropism. At the beginning about 500 pounds of well infested corn were secured from a neighboring grower and placed in shallow open bins. Small glass vials were used in the preliminary work for collecting the moths and for containers in which to obtain egg deposition and parasitism. Later in October one gallon glass battery jars were adopted for egg deposition and petri dishes inverted on pieces of cardboard for parasite cages. The amount of infested corn was increased to a ton and by the first of May 1927 a daily production of about 25,000 *Trichogramma* was obtained. At this time about 30 battery jars were in use for egg deposition. The need for greater production with less equipment now became apparent.*)

In May the battery jars were replaced by two cardboard cylinders, and tiers of plate glass shelves were substituted for the cardboards supporting the petri dish cages. With these changes parasite production increased to 200,000 daily in July.

These experiences encouraged the Association management**) to enlarge the capacity of the laboratory for 1928 production. This was done by building a compact type of corn bin which would permit the use of at least three times the amount of corn that was possible with the open bins in the same amount of space. Enough petri dishes and plate glass

---

*) The writer is indebted to P. F. Wright, laboratory assistant during May, June and July, 1927, for many helpful suggestions.

**) The expense of this experimental work was borne entirely by the Saticoy Walnut Growers Association. The stimulating effect on the writer of being provided with ample funds and unlimited freedom for experimentation cannot be underestimated.

shelves were secured to handle a daily production of a million *Trichogramma.*

Rearing Experiences in 1928.

In preparation for 1928 production a half ton of white corn was vacuum fumigated with carbon bisulphide for 24 hours and then placed in one of the rooms of the Country Insectary on August 10, 1927. The temperature of this room was maintained at about 80 degrees F. Commencing several days later, thousands of *Sitotroga* eggs were placed on the corn daily for a period of 20 days. Moths appeared at the end of 24 days.

By the first of October the old infested corn had been removed from the rearing room and used for stock feed. Pending the resumption of moth production, a million parasitized eggs were placed in cold storage in the local meat market.

Upon completion of the new bins the first of November, the half ton of newly infested corn and an additional ton of uninfested corn were placed in the rearing room. Unfortunately the precautions taken to prevent an infestation of black weevil, *Sitophilus oryzae* L., had not been sufficient, as several specimens were found in the bottom of the containers. The beetle became so numerous by March as to be troublesome during the collection of the moths.

On December 7th the remaining bins were filled with seven and a half tons of Hickory King corn newly harvested. Some of the corn, which at the time felt heavy with moisture when held in the hand, later developed mold to the extent that infestation by the moths was prevented in eighteen of the bins. Moths began to emerge from the rest of the Hickory King corn the first week in January. One hundred kernels from the upper part of one bin showed an infestation of 30% on January 30th. At this time parasite production recommenced. By the first week in February 150,000 eggs were collected daily and parasitized. The number of moths then began gradually to decrease.

In order to bring about an increase, all of the eggs collected during the first five days in March were blown back into the bins. As a result there was a marked increase on March 28th, and during the first week in April an egg production of 400 000 was attained. This peak, however, was followed by a rapid drop in production until by the middle of April the daily production was less than 50,000. During a three day period, ending April 15th, all the eggs were again replaced.

On April 20th it was found that the corn contained only about 6% of moisture. The rapid circulation of air maintained to prevent the corn from molding had evidently been continued too long. An indicator that should have received recognition was the foreign grain beetle, *Cathartus advena* Waltl. This was very abundant while the mold was developing on the corn, but about the middle of March it suddenly disappeared.

In order rapidly to raise the moisture content of the corn the entire nine tons were removed, run through a fanning mill, sprinkled with quantities of water and then replaced. This procedure occupied five days, commencing April 24th.

The percentage of infestation in the Hickory King corn was ascertained at this time. A count of the emergence holes in the kernels showed that the upper or inner portions of the bins averaged 27%, the middle 6% and the lower or outer portion 11%. Probably most of this infestation took place during the months of December, January and February.

The moisture content of the corn was raised about 3% by the treatment just described.

On the 13th day following the replacement of the corn an egg production of 150,000 was again reached. This occurred 28 days following the second replacement of eggs. Following this peak, however, production rapidly declined to zero. Many moths emerged, but hardly had their wings expanded than they dropped to the floor and succumbed to some mysterious ailment. The floor was swept twice daily, yet six hours later it would be covered with moths showing no signs of injury or wear. Many of the moths died in copula and the females were turgid with eggs.

A microscopic examination of the sweepings revealed the presence of the mite, *Pediculoides ventricosus,* in great numbers. They were found in greater abundance on the top surfaces of the bin stacks. It was found to attack both the egg and the adult (List in Colo. found that it commonly attacked the *Sitotroga* pupae when in corn, but rarely when in infested wheat).

The last full egg card to be prepared was found to be infested with many mites. An examination of egg cards prepared only a week earlier, however, showed no infestation. This rapid rise in abundance of mites indicates that conditions prior to the removal and replacement of the corn had not been optimum for their development. The factor that may have been the immediate cause of the outbreak is the high humidity maintained after the installation of the humidifier on April 28th. The relative humidity prior to that time averaged about 40%; afterward the relative humidity was maintained at an average of approximately 70%.

The mites, however, had probably been present for a considerable time, since dead moths had been observed on the floor in March. It is possible that mites instead of lack of moisture were responsible for the earlier reduction in moth production.

The mites are very susceptible to sulphur fumes and on May 19th the nine tons of corn were fumigated with 12 pounds of liquid sulphur dioxide. For several days thereafter it was impossible to find any mites, but a week later they were again plentiful. Sulphur dioxide apparently acts as a repellent and also as a poison to the black weevil. It caused great numbers of them to leave the bins and their audible gnawing of the corn ceased almost entirely. Ten more pounds of sulphur dioxide were applied late in June against the mites, greatly reducing their numbers. All of the corn was again removed July 17th. On this occasion it was noted that the *Sitotroga* population was increasing, but that 100% of the black weevils in many of the bins were dead.

From the beginning conditions in the rearing room have been more favorable to the development of *Sitotroga* than for either *Ephestia kuehniella* or *Plodia interpunctella,* for although the latter were present in

small numbers early in the season, they disappeared almost entirely. The destructive weevil can be eliminated by the sterilization of the rearing room and vacuum fumigation of the grain prior to its inoculation with *Sitotroga.* The predaceous mite would probably not be a factor in moth production if the grain was heavily inoculated with moth eggs at the start and was rapidly utilized to the limit. To insure uninterrupted production auxiliarly rearing rooms are necessary.

Description of Equipment.

The insectary of the Saticoy Walnut Growers Association (text-fig. 1) is divided into two compartments; the laboratory office and the rearing room. The rearing room ceiling and walls are lined with plaster board and the floor is of wood. It is heated by eight G. E. heating units controlled by a thermostat. The inside dimensions are length 17 ft., width 15½ ft., height 8 ft. Two windows 24 inches high extend the length of each side. A circulation of air is obtained by means of a rotary ventilator which operates whenever the wind velocity exceeds 2 miles per hour. The air passes down through floor openings and upward through an eight inch pipe that extends above the roof.

Fig. 1.

The grain containers (text-fig. 2) are shallow bins with covers made of strong slats set one-eighth of an inch apart. Each bin is 5 ft. long, 2 ft. wide and 4 inches deep, with all outside surfaces smooth. The slats

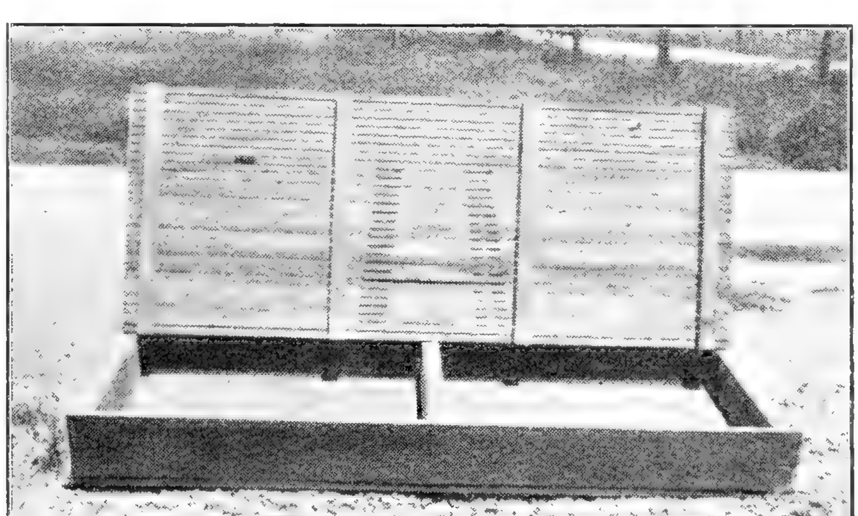


Fig. 2.

are $\frac{3}{4}$ of an inch in diameter and are surfaced on three sides. The rough side forms the inner surface of the cover. The bins should be made of kiln dried lumber.

As the bins are placed in the rearing room (text-fig. 3), they are filled full of corn and the covers fitted into place and fastened by dolpins. The bins are stacked ten high crosswise of the room, forming two rows lengthwise of 60 bins each. The inner end of each row rests on a base-board 22 inches high and the outer end on the floor, so that the bins set at an angle of about 20 degrees. The bin stacks and enclosure occupy a floor space 13 ft. by 12 ft. (text-fig. 4). The moth enclosure is 13 ft. long, 26 inches wide and 8 ft. high. The outside air enters the enclosure through a narrow ventilator and passes downward between the bins. Practically all the moths emerging from the grain accumulate in the moth enclosure. Crevices other than those leading into the grain are filled with putty.

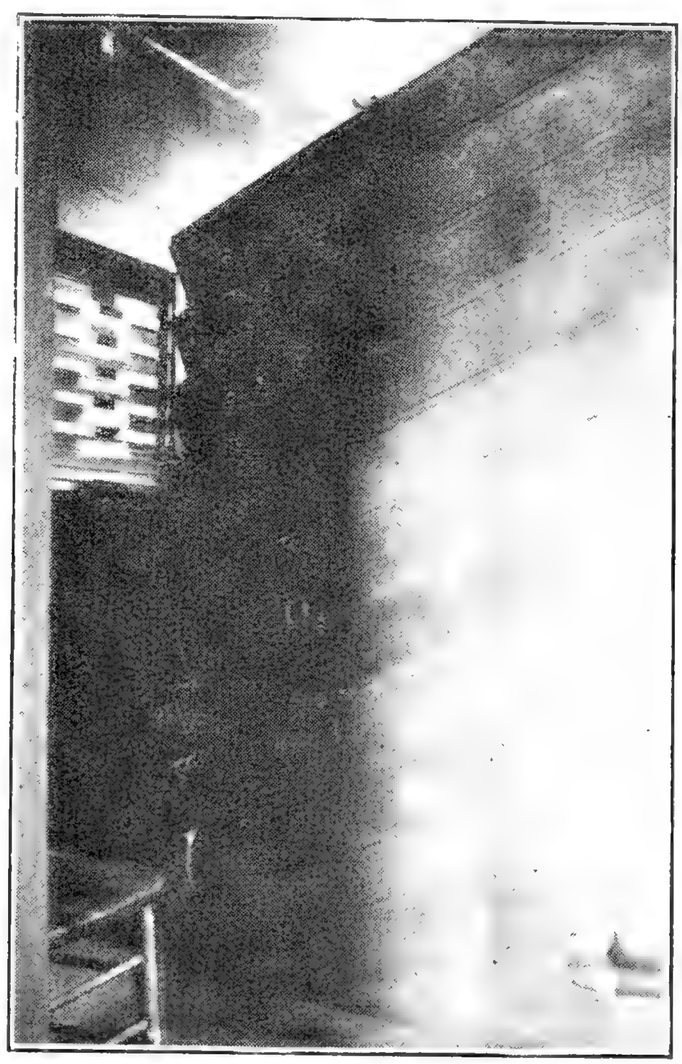


Fig. 3.

The bins were built from an experimental viewpoint and their construction precludes the use of the force of gravity in filling bins.

The moths are drawn into a $1\frac{1}{2}$ inch hose 17 feet long (text-fig. 4) and thence into an receptable consisting of a gallon battery jar (text-fig. 5) containing an interiorly directed truncated celluloid cone and a tin cover six inches in diameter and four inches high. The cover is provided with an inlet terminating a short distance above the smaller end of the cone and below a horizontal wire screen, above which is an outlet that connects with the source of partial vacuum. The moths are prevented from

Fig. 4.

Fig. 5.

Fig. 6.

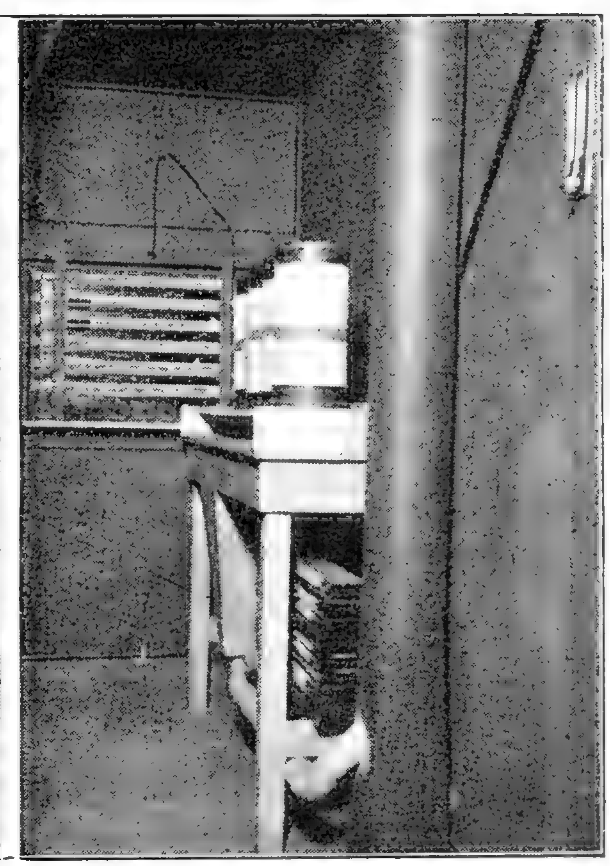


Fig. 7.

passing out of the receptacle by the wire screen and are retained in the jar by the cone. The jar can be removed from under the metal cover without loss of moths.

After removal the jar is shaken sharply, causing the moths to settle in the bottom. The moths are then dumped into the egg deposition cages (text-fig. 6). The 20-mesh screen allows many of the males to escape.

The egg deposition cages consist of smooth cardboard cylinders capped on each end with 20-mesh brass sieves (text-fig. 7). Enough moths are placed in each cylinder to cover the bottom screen so as to prevent any light from filtering through. The cages are then set over a truncated trough beneath which is placed a sheet of paper to catch the eggs dropping through. A mild current of air is circulated beneath the cages to carry away the scale dust. The equipment for preparing the eggs for parasitism consists of 18 and 30 mesh wire strainers, moth rinsing jar, filter paper and funnel, shellac and brush, and cardboard discs (text-fig. 8).

Fig. 8.

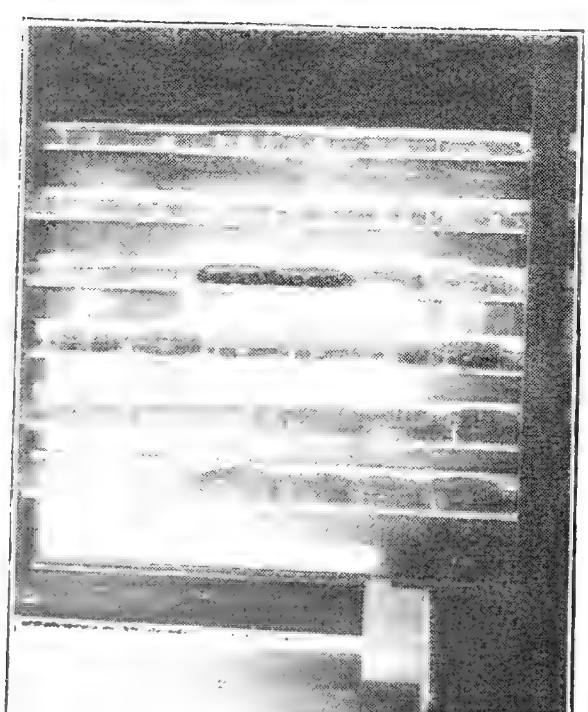


Fig. 9.

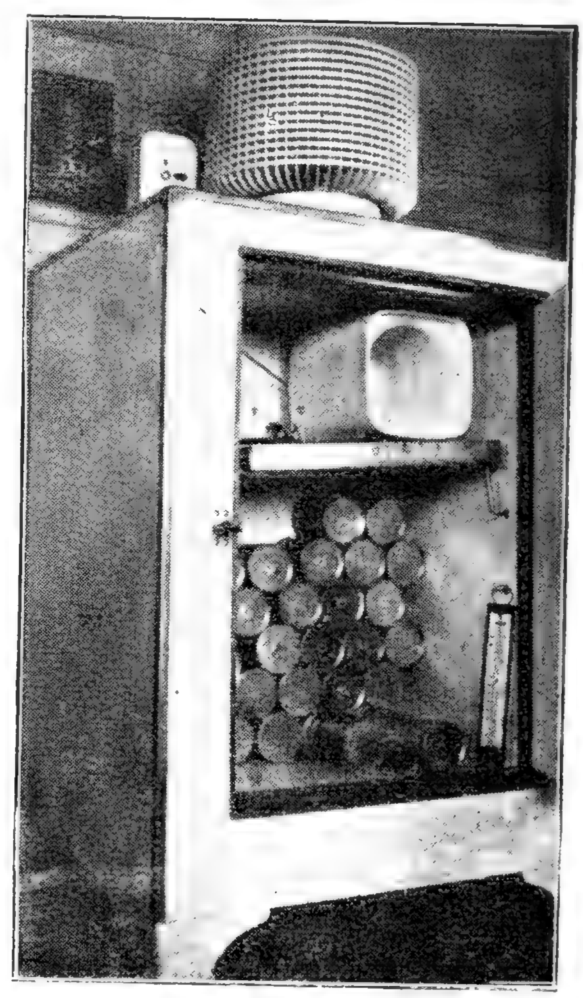


Fig.. 10

The diameter of each egg card is $3\frac{1}{2}$ inches; that of the aperture in the center $\frac{3}{4}$ of an inch. When the eggs are evenly distributed over the card the approximate number of eggs can be determined by multiplying the number of eggs visible in the low power field of the binocular

microscope by 118 or the number of times the area of the card exceeds that of the microscope field.

The inner face of each window in the rearing room is lined with a tier of six plate glass shelves 5 inches wide (text-fig. 9). The shelf capacity is sufficient for 600 petri dish cages. These are selected for their even edges so that when inverted they will make contact at every point and prevent the escape of the parasites. The inside diameter of the petri dish cages is 3¾ inches and will easily cover the 3½ inch egg cards. With this type of cage the egg cards can be removed and replaced with practically no loss of parasites.

Mailing tubes are used for the storage and shipment of parasites (text-fig. 10). Shipments are usually made at the time the parasites enter the prepupal state. Each tube is 5 inches in length and 3½ inches

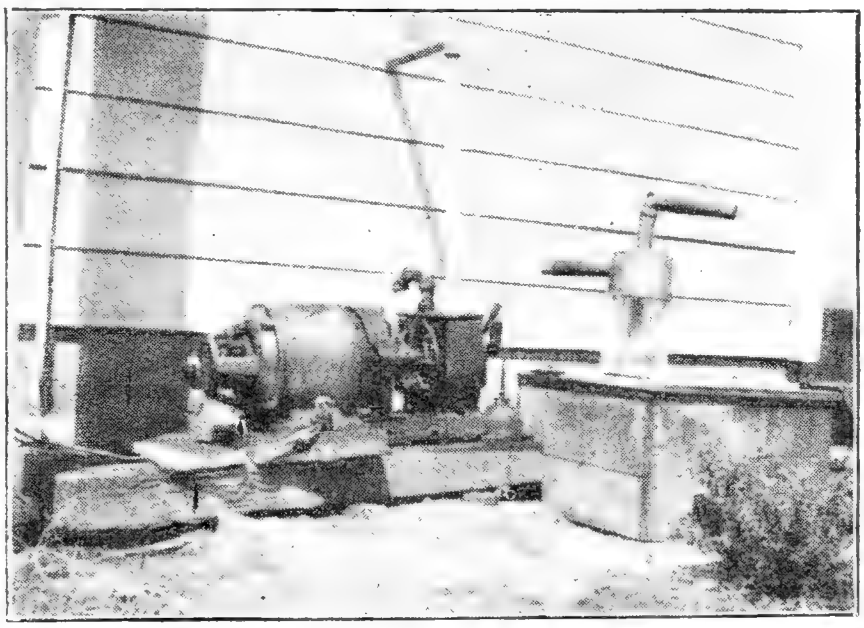


Fig. 11.

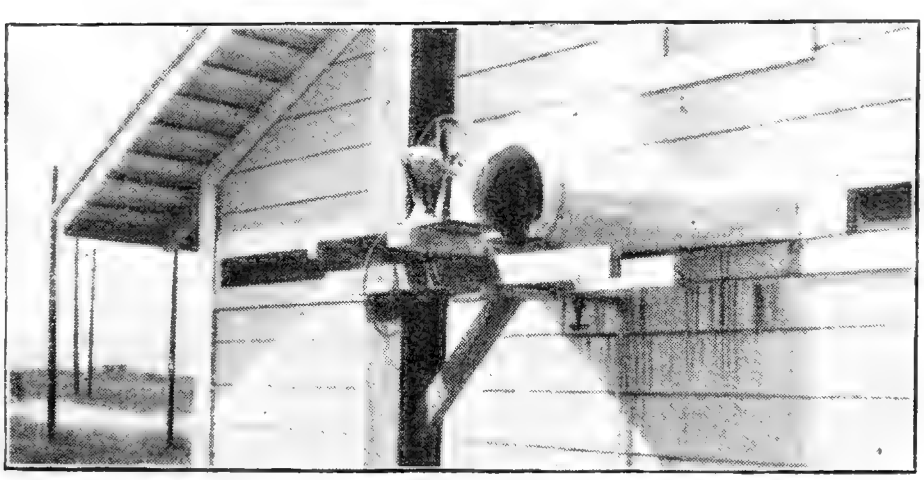
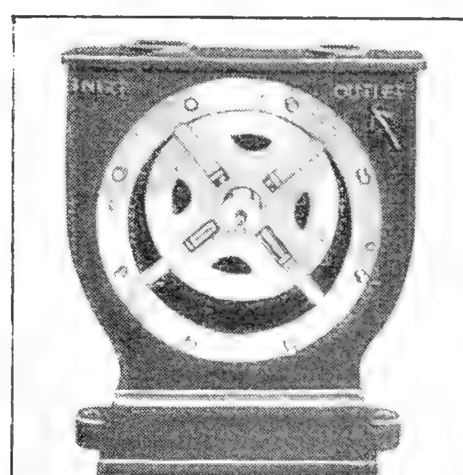


Fig. 12.



Interior Construction of Lammert Compressor

Fig. 13.

Fig. 13. The rotor is set eccentric to the main bore of the pump. Four sliding vanes or impellers positively actuated by the rotation of the rotor and by push rods extending through the shaft. These vanes are in contact with the case throughout each revolution. Each of the four vanes as they pass the inlet entrap a volume of air pushing it around the case to the outlet and forcing it into the exhaust or delivery line. This feature maintains a *uniform vacuum* or pressure at all speeds without pulsation. Each vane is equipped with an automatic take-up feature for wear, and operates against a coil spring cushion that eliminates all chatter and insures quiet operation at all speeds for the life of the pump.

in diameter and has a capacity of 500,000 eggs. The parasites are held in cold storage at daily temperatures ranging from 2 degrees C to 7 degrees C.

The Lammert Compressor is connected with the moth trap by 17 feet of 1 inch pipe (text-fig. 13). It is operated by a 1½ horse power motor (text-fig. 11), and the full amount of suction when used with a 1¼ collecting hose will not injure the moths.

Unit No	3	Horse Power	$1^1/_2$
Capacity cu. ft. per min. .	14	Floor space in inches .	21×23
Speed R. P. M.	400	Shipping wt, lbs. . .	285
Inlet and outlet pipe size .	1"	Pump size	$^3/_8$"

The humidifier is set in operation when the humidity in the moth enclosure drops below 55%. This apparatus consists of a flattened sheet iron funnel about 30 inches in length (text-fig. 12). A fine stream of water under high pressure is injected through a small opening in the ventral side. This is broken into a spray and vaporized by passing it through an 80 mesh screen. A fan forces the moisture laden air into the moth enclosure through the ventilator. Two wire screens in the funnel serve to collect the excess water in the air and pass it outward. These screens are at the larger end of the funnel and placed about four inches apart; the inner one is made of ordinary fly screening and the outer of 20 mesh screen. A daytime humidity of 80% can be maintained in the moth enclosure.

Daily Procedure in Production.

The procedure followed in the daily routine of production is as follows:

Once every 24 hours the eggs in the trough beneath the egg cages are collected, screened, and winnowed of moth appendages and scales. The cages are lightly shaken to dislodge eggs adhering to the moths.

The accumulated eggs are then poured onto freshly shellacked cardboard discs and all of the eggs not adhering are shaken off. The shellac at the moment of applying the eggs must be sticky enough to hold the eggs, but not so fluid as to engulf them. It is best applied with a small brush.

After allowing the cards to dry for about a half hour or until the alcohol in the shellac has evaporated, they are placed in the parasite cages for a period of 24 hours with night illumination.

In these cages, prior to the introduction of the new egg cards, one-third of a card from which parasites have commenced to emerge is placed to provide the stock required to impregnate at least 90% of the new eggs.

Each stock card is useable for two days, so that a six-fold increase is obtainable.

At the end of 24 hours the new egg cards are removed and suspended on hooks fastened to the lower ends of the corn bins. Three days later the parasitized eggs are black, an indication that the parasites are in the prepupal stage. The cards are then placed in cold storage retaining one-sixth as stock cards.

Following the collection of eggs and the preparation of the parasite cages the day's crop of moths is gathered by means of the vacuum collector and dumped into the egg-deposition chamber.

After remaining in the egg deposition chamber two days, the moths are poured into a wire strainer and rinsed to remove adhering eggs. These eggs settle to the bottom of the container, and the debris rising to the surface is drained off. The eggs are then separated out by means of filter paper from which, after drying, the eggs are easily brushed off. Thousands of eggs are conserved in this manner in addition to those collected daily from beneath each cage.

Storage of Trichogramma.

The optimum conditions for the cold storage of *Trichogramma minutum* have yet to be worked out.

Mokrzecki and Bragina were able to maintain *T. semblidis* and *T. fasciatum* in cold storage for ten months. They reported that hibernation sets in at 3.3^0 to 3.9^0 C and that the life cycle was 38 to 43 days at temperatures from 8.9^0 to 11.1^0 C.

The writer maintained the pupae of *T. minutum* in cold storage for 5 months at temperatures ranging from — 4^0 to 9.4^0 C. The mortality for this period, however, was almost 90%.

Zorin found the larvae of *T. evanescens* when kept at a temp. of 10^0 and 11^0 C enter the diapause and do not pupate.

The cold storage temperatures now used by the writer have a daily range from 1.7^0 to 7.2^0 C. The corresponding humidity ranges from about 40% to 75%.

Trichogramma reached maturity in 32 days when the average mean daily temperature for the period of development was 13^0 C. Twenty six days were required at 14.5^0 C.

In March 1928 a well parasitized egg card was sent to E. J. Newcomer at Yakima, Washington. He was notified that the parasites should emerge beginning March 19th. This they did, but as he had no host eggs he placed the card in the cellar where temperature was from 7.2 to 12.8^0 C. A month later he was considerably surprised to find many of the parasites alive.

There is a noticeable difference in coloration between the female parasites developing at high temperatures and those at low temperature. The bodies of the former are light yellow, while the latter are as dark as the males.

Procedure in Field Liberations.

The procedure followed in releasing *Trichogramma* in the field is as follows:

The egg cards from which parasites have commenced to emerge are placed on spindles for convenience in handling. Pieces of fine wire several inches in length are then attached to each card at points on the segments into which the card is to be cut. When they are placed on infested trees each card is cut and suspended by the attached wires. The placement of the cards in the fields as the parasites begin to emerge and their

suspension by fine wire decreases the hazard of attack by such predators as ants and lady-bird beetles.

Liberations against the codling moth on apple trees should commence at the beginning of egg deposition and continue at weekly intervals through the period of maximum egg deposition. Most of the fruit should be free of its pubescent covering before liberation begins.

Reaction of *Trichogramma* to Field Conditions.

Complete emergence in the field requires usually from three to six days. After six days the cards are examined to determine the amount of emergence. Male parasites may be found on the cards long after the females have left. The tendancy of the males to emerge first and to remain on the card insures reproduction in the field, as unmated females produce only males.

The rate of dispersion from the point of liberation varied directly with the temperature and light intensity and inversely with excessive air movement and surface moisture.

For a period of eight days many parasites were found on the ventral surfaces of leaves in the immediate vicinity of an egg card when the mean daily temperature had been 14.4° C. If the weather is cool and cloudy the parasites crawl up the wire in search of protected ventral surfaces. The cards should be suspended in the lower portion of the tree, because the parasite is usually negatively geotropic.

Light intensity appears to be the dominating factor in the activity of *Trichogramma.* Emergence from the host egg is stimulated by light; in confinement it is positively phototropic; an increase in light intensity appears to stimulate copulation, and a decrease in light intensity retards activity. Parasites are inactive at night. *Trichogramma* will crawl upward toward a 500 watt light until it meets instantaneous death at about 54.5° C.

Effect of Liberations.

In determining the effect of mass liberations the natural parasitism must be taken into consideration.

The earliest record of codling moth parasitism in the vicinity of Saticoy was made in 1924. On a walnut tree in the center of a 70 acre grove 348 eggs were found to be 5% parasitized. Most of this parasitism was due to *Prospaltella* sp. All the known species in this genus of parasites attack armored scales or white flies. That its attack on the codling moth egg is accidental is borne out by the fact that so far only males have been obtained. It is a factor, however, in the valuation of natural parasitism. In 1926, on a walnut tree, 461 eggs were found to be 49% parasitised. In 1927 and 1928 the natural parasitism on walnut codling moth eggs was very light. Hundreds of walnut trees were closely examined each year by four trained inspectors. The highest number of parasitized eggs found on any walnut tree since 1926 was twelve and these were all due to *Prospaltella.*

In 1928 it was found that the parasitism of codling moth eggs on "dooryard" pears and apples were in some cases nearly 50%. Several hundred of the parasitized eggs were examined and it was found that 30% of the parasitism was due to *Prospaltella.* Unlike *Trichogramma* the larva

of *Prospaltella* is eel-like and active and voids its excrement prior to pupation. The presence of excrement indicates *Prospaltella* as having parasitized the egg.

In 1927 many thousands of *Trichogramma* were liberated in the walnut groves of the Association, but accurate checks upon the percentage of parasitism were made only on seven trees (see tables 1 and 2). The percentage of parasitism can be first ascertained about two weeks after the first liberation, when the parasitized eggs turn black. The effect of the release of *Trichogramma* was to increase the percentage of parasitism from less than 1% up to as high as 52.4% on the most highly infested trees.

In 1928 fewer parasites were available owing to the destruction of the laboratory host by *Pediculoides*. Cold storage parasites, however, were liberated on one highly infested walnut tree and also on ten apples and pears on the Lloyd-Butler Ranch. As in 1927 a marked increase in parasitism followed the liberations (see tables 3 and 4). A comparison was made between the artificial parasitism obtained on the pears and apples on the Lloyd-Butler Ranch and the natural parasitism on check pear and apple trees located three miles distant. The parasitism on these check trees was the highest of many trees examined for use as checks. The highest natural parasitism was 45.7% and the highest artificial parasitism was 72.9%. The parasitism on each tree in the test plot was higher than 45.7%, the maximum natural parasitism.

In May 1928 the writer sent 40,000 parasitized eggs to C. H. Alden in Georgia. In June Alden reported that the parasites emerging from them were very effective, as over 200 eggs were parasitized from approximately 220 codling moth eggs under observation.

Possibilities in the Use of Trichogramma.

The possibilities in the practical use of *Trichogramma* in biological control work deserve full investigations, since the production of this parasite in large quantities is now feasible.

Within the last two years over a score of entomologists have turned their attention to *Trichogramma* and are investigating its use against the codling moth, the European cornborer, sugar-cane borer, the pecan nut casebearer, the corn-ear worm, celery leaf-tyer, tea tortrix, oriental peach moth and rice moth.

In case of field crop insects such as the European Cornborer, early mass liberations, when host eggs are fairly abundant, by accelerating field reproduction should cause an early effective parasitism and a high degree of control.

In the control of orchard insects, such as the codling moth, parasites should be liberated each week or twice a week during the first part of the egg deposition period of the moth including the peak of egg deposition. Enough parasites should be liberated in one season to reduce the moth population to such a point that further liberations would not be required for several seasons. It is estimated that ten to fifty thousand parasites per tree would bring about this result.

In the control of the codling moth the first effort will be to substitute *Trichogramma* for the cover spray applications of lead arsenate and thus

eliminate the arsenical residue problem. It is possible that in this field we may see thee first successful use of *Trichogramma* in biological control.

The basis for commercial control by means of this parasite is mass production at a low cost. It is probable that in the near future standardized methods in rearing will reduce the cost of *Trichogramma* production to less than ten dollars per million. Such low cost production will permit the liberation of enough parasites in local defined areas to over-balance nature, and by parasite superiority cause a reduction of the host to a point below the economic minimum.

With Dr. L. O. Howard we look forward to the work on *Trichogramma* with great confidence as eventually showing something very practical.

Table I. Weekly observations of the Natural and Artificial Parasitism during a three-years period on one tree near the center of a 30-acre walnut grove.

		May		June					July	
1926	live eggs	68	61	154	196	131	48	35	86	1
Natural	hatched ,,				No record					
parasitism	black parasitized	0	5	20	29	38	15	12	5	0
1927	live eggs				50	54	11	3	7	0
Artificial										
parasitism.	hatched ,,				0	5	34	14	0	0
	black parasitized				0	26	51	20	17	4
1928	live eggs		64	279	156	131	171		107	
Artificial										
parasitism	hatched ,,		20	35	19	119	116		105	
	black parasitized		2	3	53	184	52		23	

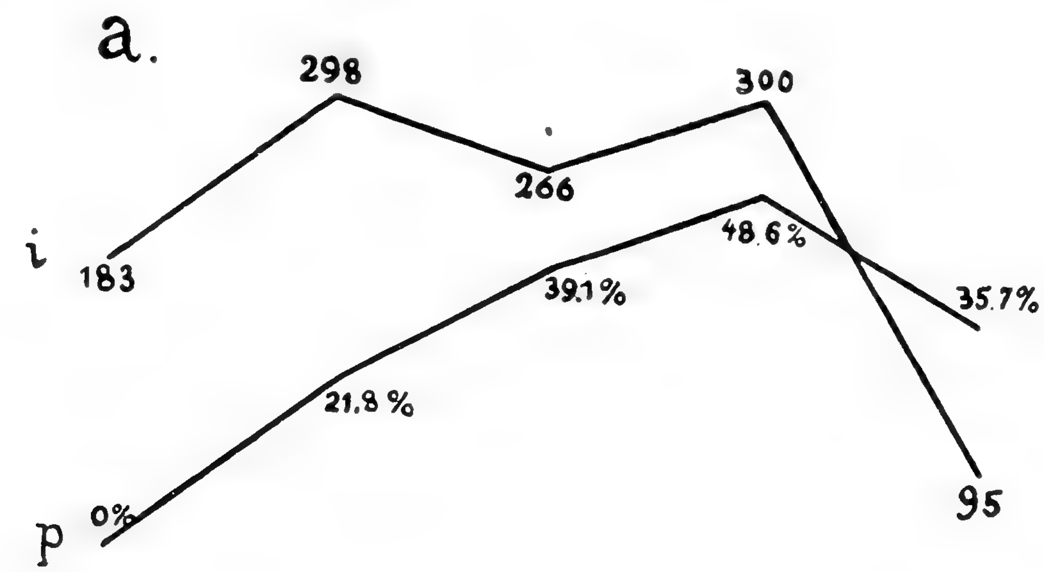
In 1927 40,000 Trix were liberated one week prior to the first inspection.
In 1928 9,000 ,, ,, ,, at the first inspection.
Black parasitized eggs appear the second week after liberation.
Natural parasitism on the walnut codling moth in 1927 and 1928 was very light.

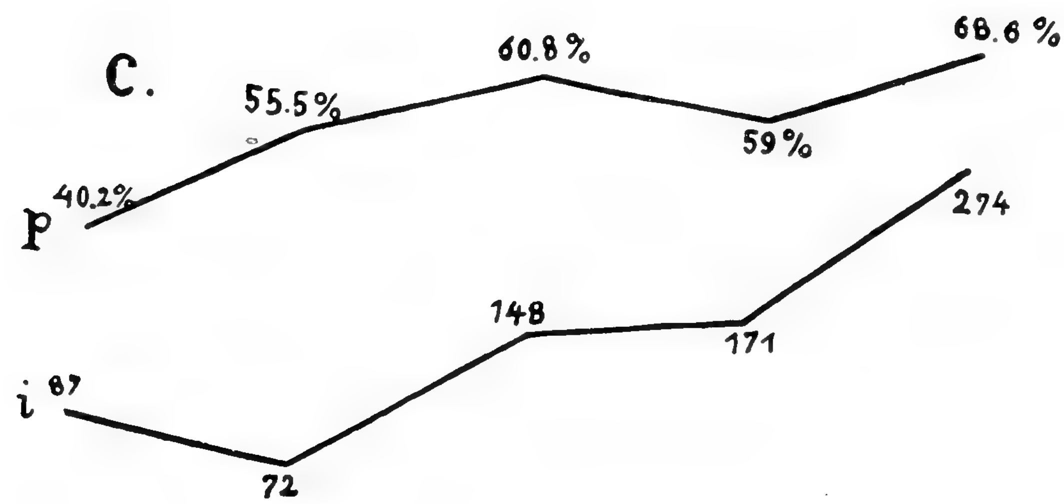
Table II. Parasitism resulting from the liberation of approximately 100,000 Trix on six walnut trees June 27 and July 6, 1927.

	A 25,000	B 15,000	C 10,000	D 15,000	E 10,000	F 25,000
Hatched eggs	127	68	124	94	88	109
Parasitized	140	26	30	66	41	47
Percent ,,	52.4 %	27.6 %	19.5 %	41.2 %	31.8 %	30.1 %

Natural parasitism was less than 1 %.

The cards were placed on the trees 1 day prior to emergence (Fig. a).





a. = Infestation and parasitism gradients. June 30 to August 1.
c. = 4 apple trees. June 1 — June 29. 13,000 Trix released 18 days prior to first inspection.

Table III. Natural plus Artificial Parasitism in 1928 on "dooryard" apple and pear trees during first brood egg deposition. May 25 — June 29 on pear.

	P 1 1,200 May 5	P 2 3,800 May 5	P 3 4,500 May 13	P 4 1,200 May 5	P 5 2,500 May 5	P 6	P 7	C 1	C 2 check trees are 3 miles west	C 3
Hatched	63	145	154	105	49	45	22	157	110	139
Parasitised	170	161	257	267	67	72	19	75	60	117
Percent	72.9%	52.6%	62.5%	71.7%	57.7%	61.5%	46.3%	32.3%	35.3%	45.7%

	A 1 3,000 May 13	A 2 3,800 May 5-13	A 3 2,500 May 13-20	A 4 3,500 May 5-15	C 4
Hatched	56	47	92	60	103
Parasitised	121	80	156	83	18
Percent	68.3%	63%	62.9%	58%	14.8%

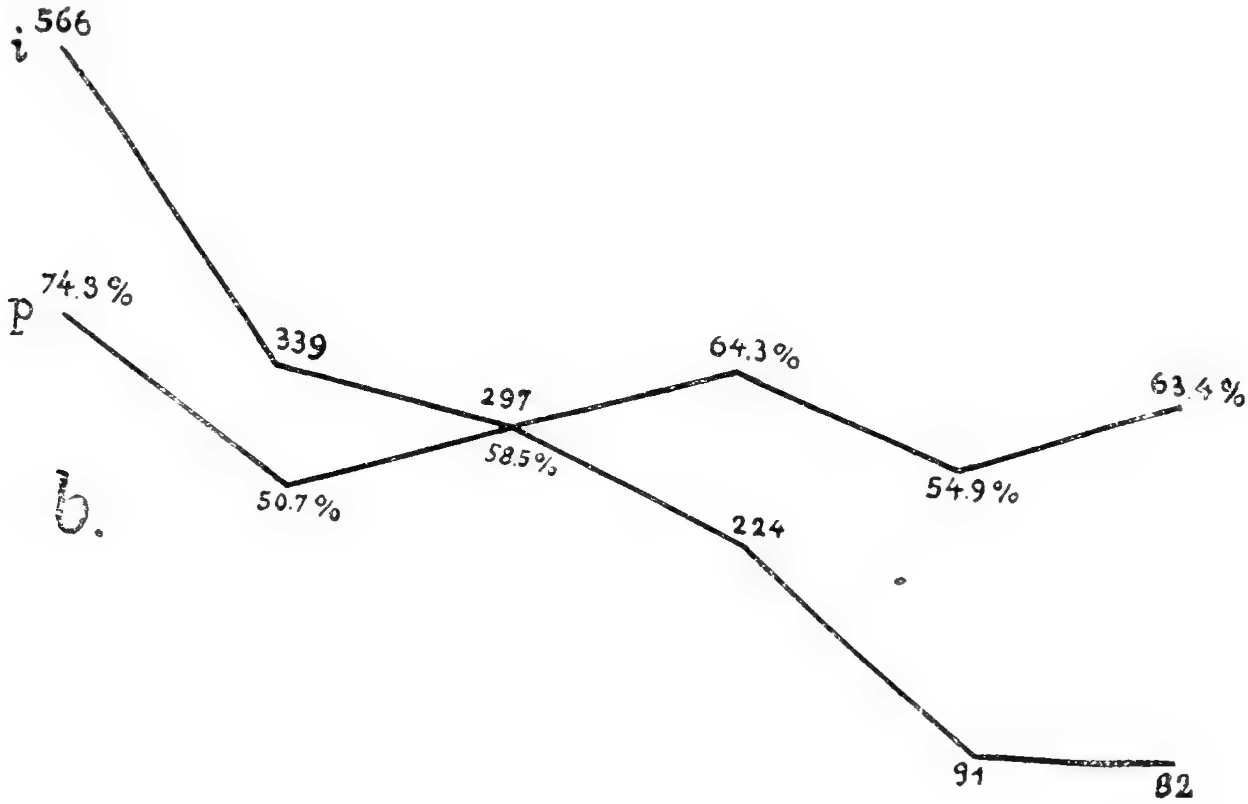
All trees marked P and A form a small "door-yard" orchard on the Lloyd-Butler Ranch.

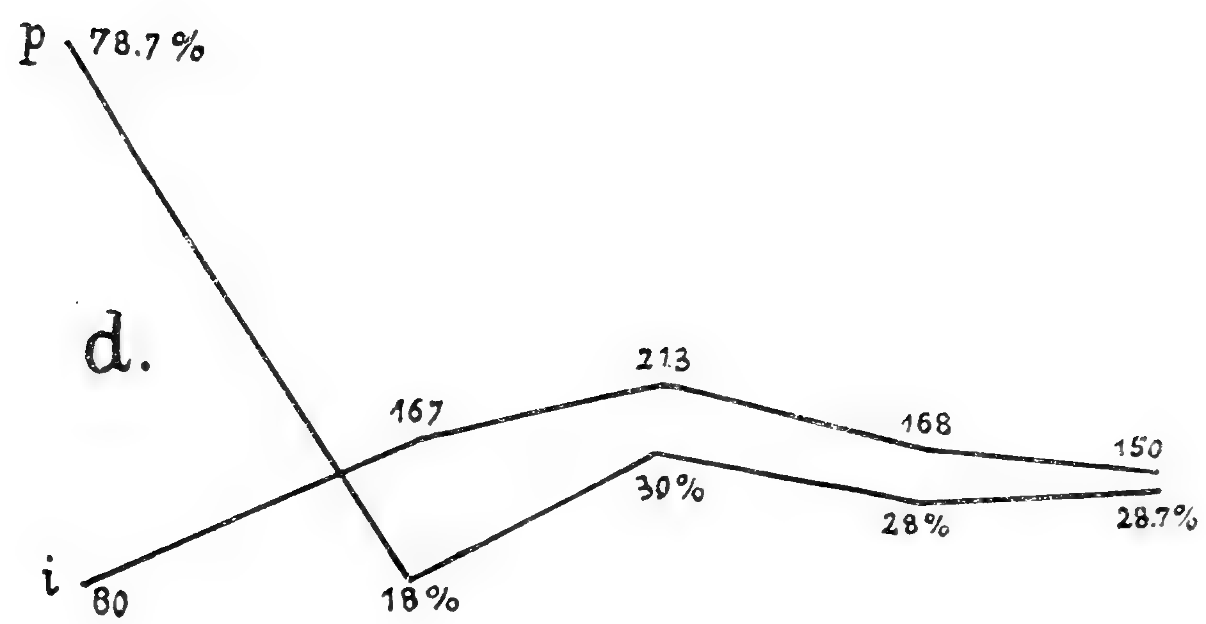
Cards were placed on the trees the day emergence began

Table IV. 1928.

Infestation and Parasitism Gradients based on six weekly inspections.

The maximum oviposition on apples occured one month later than on pears owing to the retarded development of the apple trees. (Fig. b, c, d).





b. = 7 pear trees. Inspected May 25—June 29. 13,009 Trix released 20 days prior to first inspection (on 5 trees).

d. = 3 pear trees. May 28 — June 28. location: 3 miles west of experimental plat. 30 % of the parasitism due to *Prospaltella* sp.

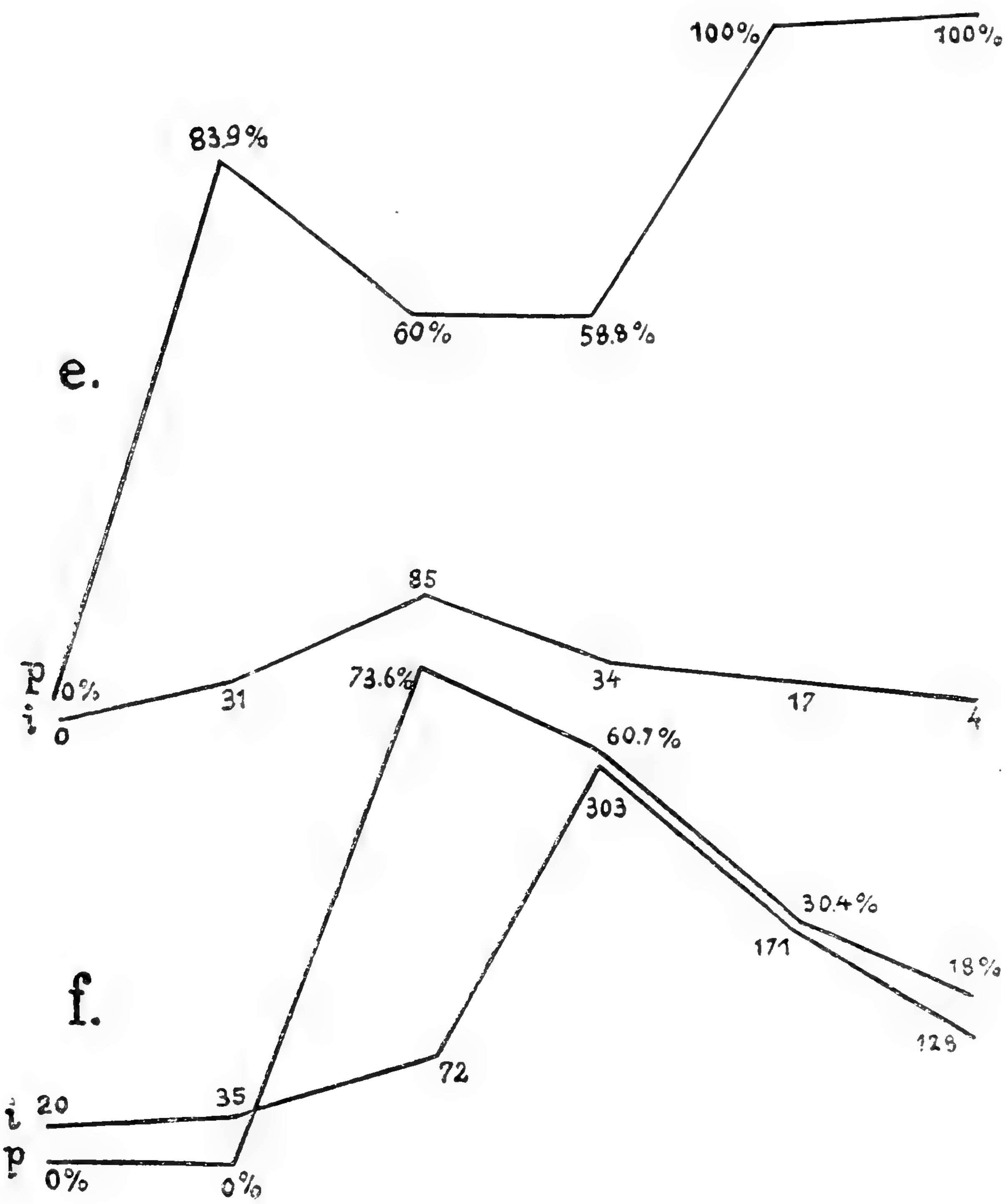


Table V. Infestation and Parasitism Gradients on a walnut tree in center of 30-acre grove.

1927
e. = June 18 — July 22
40,000 Trix released one week prior to first inspection

1928
f. = May 29 — July 2
9,000 Trix released at first inspection

Literature

1. den Doop, J. E. A. — 1918. The Spread of *Trichogramma*, the Egg-parasite of *Heliothis obsoleta*, on the East Coast of Sumatra; in Mededeelingen van het Deli Proefstation 10: 213—220. (In Dutch.)
2. Harland, S. C. — 1915. Notes of *Trichogramma minutum;* in West Indian Bull. 15: 168—175.
3. Hase, A. — 1925. Contributions to the Life History of the Hymenopterous parasite *Trichogramma evanescens* Westw.; in Arb. Biol. Reichsanst. Land- und Forstw. 14: 171—224, illus. (In German.)
4. Holloway, T. E., Halley, W. E. and Loftin, U. C. — 1928. The Sugarcane Moth Borer in the United States; in Techn. Bul. U. S. D. A. 41:40—63 illus..
5. Martin, C. H. — 1928. Biological Studies of Two Hymenopterous Parasites of Aquatic Insect Eggs; in Entomologica Americana, 8 105—131 illus.
6. Marchal, P. — 1927. Contribution à l'étude génotypique et phénotypique des Trichogrammes. Les Lignées naturelles de Trichogrammes; in C. R. Acad. Sci. France. 185: 489—493, 521—523.

7. Mokrzecki, S. A. — 1913. Report on Injurious Insects and Diseases of Plants in the Gov. of Taurida during the year 1912. Simferopol pp. 1—23.
8. Mokrzecki, S. A., and Bragina, A. P. — 1916. The Rearing of *Trichogramma semblidis* and *T. fasciatum* in the Laboratory and Temperature Experiments on them. Salgir Exp. Pomological Station, Simferopol (Crimea).
9. Portchinsky, I. A. — 1913. *Phalera bucephala* L. and its Importance for the Artificial Breeding of *Pentarthron semblidis* in winter; in Memoirs Bur. Ent. Sci. Committee. Central Board of Land Admin. and Agr. 10: 1—16, illus. (In Russian.)
10. Radetsky, A. F. — 1913. *Orphthora semblidis,* description, biology and utilization of it in the struggle with C. pomonella L. Turkestan Ent. Sta. Tashkent. 28 pp. (In Russian.)
11. Riley, C. V. — 1882. Efficacy of Chalcid Egg Parasites; Amer. Nat. 16: 914—916.
12. Severin, H. C. M. and H.H. P. — 1908. Habits of the American Sawfly *(Cimbex americana)* with Observations on its Egg Parasite *Trichogramma pretiosa;* in Trans. Wis. Acad. Sci. Arts and Letters. 16: 61—76.
13. Vuilett, A. — 1914. Utilization of certain Phytophagous Insects in Combating Pests of Cultivated Plants; in Revue Scientifique, Paris. 526—530.
14. Zorin, P. V. — 1927. A Method of Rearing *Trichogramma evanescens* Westw.; in Defense des Plantes. 4: 316—319 (Leningrad). (In Russian.)

Moth Borer Control in British Guiana.

L. D. Cleare Jr., F. L. S., F. E .S.,

Government Entomologist, British Guiana.

Nearly half-a-century ago Eleanor Ormerod (1) reported upon the moth borers of sugar-cane in British Guiana, and made recommendations for their control. As long ago as that *Diatraea* were serious pests of sugar-cane in this country, and even to-day, without a doubt, Moth Borer or "Small Moth Borers" as they are known locally, are the most important enemies of sugar-cane in British Guiana.

It is true that *Castnia licus* F. (2), the Giant Moth Borer as it is called, came into prominence some twenty years ago and held the premier place as a pest of this crop for several years, but *Castnia licus* may now be considered a thing of the past as far as this crop is concerned, for its control in this country has been accomplished. This insect therefore will not be dealt with here, and the remarks that follow will be confined to the Small Moth Borers.

Species Concerned.

Three species of *Diatraea* attack sugar-cane in British Guiana, namely *D. saccharalis* F., *D. canella* Hamps., and *D. lineolata* Walk. Of these species *saccharalis* and *canella* are accountable for almost all the damage occurring in the crop, and of the two *canella* is probably the more dangerous, as it is the more difficult to keep in subjection under prevailing conditions. The reason for this is probably to be found in the more secretive habits of oviposition of *canella*, for hand picking of egg-masses of these insects forms an important part of the control measures undertaken in this Colony.

Damage.

The actual loss in sugar caused to the industry in British Guiana by these insects has not been determined. Careful estimates have been made, however, of the damage inflicted. Taken over the whole colony it may be said that 95% of the stalks are damaged to the extent of 25% of their joints. There is some degree of variation from these figures both with regard to variety of cane as well as to the denomination of the cane, that is as to whether it is plant cane or ratoons, and also as regards the number of the ratoon.

The infestation for the seedling D 625 may be taken as 96.1% stalk and 26.0% joints or 24.9% of total joints. As of a total of 59,271 acres under cane in 1927, some 41,000 acres were planted with the seedling D 625, or about 75% of the total area in sugar-cane in the Colony, the

figures given above may be considered as fairly representative of the Colony generally.

Control Measures.

Hand Picking. — Moth borer control in British Guiana mainly consists of the hand picking of egg-masses of the moth and the collection of larvae and pupae by the removal of "dead hearts", a process known locally as "cutting out" borers. For this work children are usually employed, although within recent years the tendency has been to employ young women. Such individuals, formed into a "borer gang", are paid according to results, and soon become so skilful at the work that the most proficient among them will earn as much as other labourers employed at more arduous tasks.

The term "cutting out borers" well describes such work, and is literally what takes place. Each individual in the gang is armed with a large cheap knife, and on observing a "dead heart" in a stool of cane removes the entire shoot as close to the ground as is possible. The shoot is then cut open and if it is found to contain either a larva or pupa this is removed and placed in a small flat tin which is carried by every person of the gang, the kind that is most popular being a one-ounce tobacco tin which measures two and a half inches in diameter and one inch deep.

The leaves of the cane plants are next examined, and any unparasitized egg-masses observed are removed attached to a piece of the leaf about two inches in length. The egg-masses are also kept in a separate tin of the same kind as used for the larvae. Egg-masses that have been parasitized a few days previously are easily recognised by their black colour and these are not collected. If parasitism has taken place within the previous four days, however, there will be no such black coloration and for this reason it is inevitable that some egg-masses that are parasitized, but which have not yet turned black, are removed in these collections. Egg-masses thus collected by the gang are therefore not destroyed on the day of collection, but are kept for a period of four days in a manner described later.

At the end of the day an overseer counts the larvae, pupae, and egg-masses collected by each individual, and they are paid weekly for the work. The prices paid vary according to the prevalence of these insects and eggs, but may be taken at an average of 8 cents per 100 for larvae and pupae, and 1 cent each for egg-masses.

The number of insects collected on a plantation in this way may run to large numbers, and the cost amount to several hundred dollars annually. On a plantation where these figures have been kept for several years the annual number of moth borer larvae and pupae collected in this manner has averaged 921,000, while the egg-masses collected have amounted to about 50,000 annually. At the prices mentioned above, namely 8 cents per 100 for larvae and pupae, and 1 cent each for egg-masses, this represents an annual expenditure of over $1,200 on an area of about 1,500 acres, or roughly 80 cents per acre. To this must be added the cost of supervision, — drivers and overseers — or say another $400 a year, bringing the expenditure to about $1 per acre.

Cultural Control. — Much of the damage inflicted by moth borers in British Guiana could be reduced by the changing of some cultural practices and the discontinuance of others at present in vogue, as has been pointed out previously by the writer (7). But sugar-cane is a crop in which routine is not readily changed and measures may be recommended for many years before they are adopted by the plantations. The majority of these control measures may be classed under the general head of Cultural Control.

This involves in most instances measures directed not only against the moth borers, but which also embrace questions connected directly with soil amelioration, disease control, or other biological factors. These measures include the abolition of old banks in plant fields; the non-burning of trash prior to reaping; and the destruction or disposal of refuse in fields. A short account of these may be of interest.

Abolition of Old Banks. — When a ratoon crop no longer produces remunerative yields, the field may be "abandoned" and thrown out of cultivation for a period, under which circumstances it may be allowed to go to grass or may be "flooded"; or it may be replanted immediately in cane to run on for another period until it again ceases to produce profitable returns.

When it is decided to replant a field after a ratoon crop has been taken, without an interval of abandonment or flooding, such replanting usually takes place several weeks after harvesting, and the new rows are formed between the stubble of the ratoon crop. During the interval no attempt is made to remove the stubble, and this springs in the usual manner of ratoons, forming rows between which the new "tops" are planted. In this manner the old ratoon stubble may be allowed to continue its growth until it tends to become a danger to the new plants through its heavy shade. But long before this, it is a danger from the point of view of moth borer attack, for "dead hearts" appear amongst these canes and the moths emerging from them infest the new plants. This, however, is not the end. When this ratoon stubble, now infested with moth borer, is cut down to give the plants better opportunities, it is cast aside upon the "trash bank" and here the borers either complete their development, if far enough advanced to do so, or not finding sufficient sustenance in the shoots leave these and, wandering off, find agreeable conditions in the adjacent young plants, which they proceed to attack. In addition, the weeding down of the entire ratoon spring may not take place at once, but may only extend to every alternate row, leaving the other rows still breeding moth borers, or may not be followed by the ploughing out of the stubble for several weeks, by which time a further ratoon spring may have taken place. The danger of such "old banks" is therefore very real. Fortunately, of late years they are being dealt with more effectively.

Non-burning of Fields. — The various merits and demerits of this practice will not be gone into here. There cannot be the slightest doubt, however, that a large number of the natural enemies of the moth borer, in the form of parasitic and predaceous enemies, present in the fields at the time of reaping, must be destroyed by such burning. The practice has much to recommend it when considered from the point of economy in reaping-cost, especially where there is a shortage of labour. While the

burning may serve in a measure to kill the moth borer larvae contained in the top, such destruction is by no means complete, as will be seen by the number of tops found to contain living larvae after the fields have been burnt. This will be dealt with later.

Destruction and Disposal of Refuse in Fields. — A very important source of infestation is to be found in the refuse in fields, and by this is meant principally seed-pieces that have been rejected as being unsuitable for planting, or surplus material of this kind left around either in the ratoon fields where it has not been collected, or in the plant fields where it has not been used. Much of this material is in the first place rejected because of the extensive damage by borer to the joints, or more often on account of the destruction to buds, itself often caused by borers. It can at once be understood that such material must form a ready source of infestation to the fields in which it occurs. Examinations of 2,000 seed-pieces or "tops", in fields that had been burnt in the usual way, have given an infestation of 15% containing either living larvae or pupae at the time of examination. Only 50% of these sets, however, were sound and entirely free from moth borer attack, the other 35% having borings that were empty at the time of examination.

Much remains to be done in the destruction of such refuse material in British Guiana, and although several recommendations have been made in this connexion they have not been adopted generally by the plantations.

Treatment of Seed Cane. — As previously mentioned 15% of all seed-pieces are infested with moth borer prior to being planted, and quite apart from the fact that such infested material cannot be as suitable material for planting purposes as borer-free sets, it has been found definitely that the larvae contained in such seed-pieces continue their development therein, and either emerge as moths to infest the field by egg-laying, or bore their way into the young plant-shoots and destroy them. Selection of planting material to secure borer-free seed-pieces has been advocated, but it must be admitted that this is not always practical. For this reason some means of treating seed cane prior to planting has been sought. Early in 1921 the writer carried out investigations on the submersion of seed cane in cold water for the destruction of the contained moth borer larvae and it was found that 72 hours of such submersion killed all the contained larvae and pupae. Germination tests proved that the seed cane was unaffected by such treatment, in fact if anything growth was stimulated. The writer therefore recommended such treatment locally, and published this recommendation in October 1922, and again in 1923 (7).

In 1922 Holloway and other investigators working in the United States, after experiments with hot water treatment, carried out trials with cold water and arrived at a similar conclusion. Since that time the cold water treatment of seed cane has been extensively recommended in the United States.

This method of attacking moth borers offers one of the most effective forms of control in British Guiana, and apparently gives promise of similar advantages in the United States. While it has been practised in British Guiana to a limited extent, it has not been adopted generally by the sugar estates.

Biological Control.

Methods of Biological Control will for convenience be divided into three heads, viz. (1) introduction of foreign parasites (2) conservation of native parasites, and (3) the rearing of indigenous parasites.

Introduction of Foreign Parasites. — Only one trial has been made to introduce foreign parasites of *Diatraea* into British Guiana. In 1925 Mr. H. E. Box (8), while employed by certain sugar interests in British Guiana, carried out an introduction of the Cuban Tachinid Parasite, *Euzenilliopsis diatraeae*, from Porto Rico. The introduction as such was successful, a small number of insects were liberated in the cane-fields in British Guiana, and subsequently Mr. Box recovered a pupa of this insect in the area. As to the success of the venture from a commercial point of view, it is perhaps still too early to draw definite conclusions, although it may be stated that the insect has not been taken again in the area.

Conservation of Indigenous Parasites. — Moth borers are attacked by a number of insect parasites in British Guiana, and thirteen of these enemies have been recorded. Of these two are egg parasites, ten larval parasites, and one pupal parasite. With the exception of two Dipterous larval parasites these insects are all Hymenoptera, some of the larval parasites being Braconids. The two egg parasites are the most effective checks, and have been most studied.

For many years the conservation of native parasites has been practised on several of the larger plantations in British Guiana, and the work in this respect embraces both egg and larval parasites. With gangs removing large numbers of the egg-masses from the fields it is inevitable that a good deal of parasitized material, not distinguishable as such at the time, would be removed, and if the egg-masses were destroyed immediately the benefit of these parasites would be lost. For this reason all egg-masses, or "clusters" as they are called locally, collected by the borer gang, are kept for four days after collection, by which time egg-masses that are parasitized develop their characteristic black colour. These parasitized clusters are then returned to the fields from which they were obtained and the remainder destroyed. The number of parasitized clusters obtained in this way has been found to be about 38% of the total number collected.

The conservation of larval parasites is, unlike the above, entirely dependent on the individual, and here much depends on the training of the gang, the proficiency of the individual labourer, the care with which the gang has been selected, and the supervision. The individual labourers are taught to recognise the cocoons of Braconid parasites, as well as larvae that are parasitized, and when these are found in dead hearts they are removed, placed in separate tine, and at the end of the day brought in and suitably stored. On emergence the parasites are returned to the fields.

Rearing of Indigenous Parasites. — Today the rearing of indigenous parasites of moth borer is receiving considerable attention and is looked upon with much favour as being one of the most promising means of attacking these insects. This work is one of the more recent methods of attacking the moth borer and was first undertaken by the writer in British

Guiana in 1921. During the present year it has been recommended also in the United States.

The technique employed in obtaining these parasites is somewhat different in the two countries, and only the method used in British Guiana and devised by the writer will be dealt with here. A more detailed account of this work has appeared elsewhere recently (9).

The basis of such work is to obtain eggs of *Diatraea* artificially in which the parasites *Trichogramma minutum* Riley and *Prophanurus alecto* Cwfd. are reared, the parasites thus obtained being liberated into the cane fields.

Egg-masses of *Diatraea* are obtained artificially by rearing moths from larvae procured in the collections of the borer gang, or by boys specially employed for this purpose. The larvae thus obtained are kept *in situ* in the dead hearts until pupation takes place, being examined at intervals during the period.

Oviposition takes place in cages in which the moths are supplied either with fresh green cane leaves or dried leaves. The egg-masses thus obtained are removed each with a piece of the leaf and these are placed in special boxes for parasitism. These parasitizing boxes are flat glass-topped boxes, somewhat like an ordinary insect case, with an extra bottom of asbestos or other absorbent material, across which are placed a number of bands held in position by screw bolts and winged nuts. The pieces of leaf bearing the egg-masses are placed on the asbestos bottom, previously moistened to prevent drying of leaves and egg-masses, and are then held down by the bands. Parasites are admitted to the box by tubes through holes in one side of the box, and in a short time may be seen at work on the egg-masses.

A large number of parasitized egg-masses can be produced in this way without undue difficulty and on one estate, with only ten ovipositing cages working, about 300 parasitized egg-masses are produced daily or 26,250 *Trichogramma* parasites per day. On another estate, the output is about 30,000 egg-masses per quarter of 75 working days or say 35,000 parasites per diem.

In conclusion it may be said that, although the method of control of moth borer generally practised on sugar plantations in British Guiana is hand picking, on a few of the larger properties more advanced methods are in operation, and as far as scientific investigation of the problem is concerned British Guiana is not behind other sugar producing countries. Indeed some of the measures now recommended in other countries, such as the non-burning of fields, treatment of seed-cane with cold water, and the artificial rearing of egg-parasites, were first instituted in British Guiana.

Literature.

1. Ormerod, E. A. — 1879. Sugar-cane Borer of British Guiana. In Proc. Ent. Soc. London, pp. XXXIII—XXXVI, 1879.
2. Quelch, J. J. — 1910. Report on the Giant Moth-Borer with notes on the Small Moth Borer and the Beetle-Borer. Georgetown, pp. 32, 1 plate, 1910.
3. — 1911. Interim Report (April) and General Report (June) on Insect Pests to Messrs. Curtis Campbell & Co., & Messrs. Booker Bros., McConnell & Co., Ltd. 1911.
4. — 1914. Reports (April & Sept.) on the Control of the Small Moth-Borer, *Diatraea sacharalis* and *Diatraea canella*, of the sugar-cane with some general notes, to

Messrs. Curtis Campbell & Co., and Messrs. Booker Bros., McConnell & Co., April and September, 1914.

5. Moore, H. W. B. — 1912 to 1921. Reports (monthly) and General reports (annual) on Insect Pests to Messrs. Curtis, Campbell & Co., and Messrs. Booker Bros., McConnell & Co., Demerara.

6. Cleare, L. D., Jr. — 1920. Annual loss caused through Insects in British Guiana. In Journ., Board of Agriculture, British Guiana, Vol. XIII, pp. 115—126, 1920.

7. — 1922 and 1923. Notes on the Small Moth-Borer of Sugar-cane in British-Guiana. In Bull. Entomological Research, Vol. XIII, pp. 457—468, 1923; and Journal Bd. of Agric., British Guiana, Vol. XV, pp. 163—184, 1922.

8. Box, H. E. — 1926. Sugar-cane Moth-Borers (Diatraea spp.) in British Guiana. In Bull. Entomological Research, Vol. XVI, pp. 249—266, 1926.

9. Cleare, L. D., Jr. — 1928. A Method for the Rearing of Egg Parasites of the Sugar-cane Moth-Borers. In Bull. Entomological Research, Vol. XIX, pp. 31—38, 1928.

The European Corn Borer, Pyrausta nubilalis Hübn., its History and Status as a Problem in the Dominion of Canada.

H. G. Crawford, Chief of the Division of Field Crop and Garden Insects, Entomological Branch, Department of Agriculture for Canada, Ottawa, Canada.

(With one text-figure.)

History of the European Corn Borer in Canada.

The discovery of the European corn borer in the United States by Vinal in 1917 was a matter of more than passing interest to Canadian entomologists.*)

The record of its establishment in Massachusetts was followed in Canada by a survey in 1919, of the Maritime Province for its possible occurrence on the Canadian seaboard, and later in the season, following its discovery in western New York, by a sketchy survey in the adjacent Canadian area in the province of Ontario. This survey was carried on very late in the season and was terminated by unfavourable weather without positive result. In 1920, the survey in Ontario was continued, and the presence of the insect in Canada definitely established by recoveries of larvae in the field on August 10. A re-organization of the scouting activities followed and a joint and thorough survey of the southwestern Ontario area was undertaken by the Entomological Branch of the Department of Agriculture, Canada, with the co-operation of the Provincial Entomologist of the province of Ontario. By the end of the scouting season (1920), the European corn borer was found to be present over a territory embracing 2780 square miles along the lake Erie shore in the province of Ontario, in two distinct areas; a small one of five townships at the northeastern end of the lake opposite New York state, and a larger one of thirty townships along the middle of the Canadian shore. The spread of the insect from that time has been under yearly observation and

*) The corn crop is one of great importance in Canadian agriculture. In estimated annual value for 1921, it ranked fifth among the field crops of the Dominion as a whole and third among those of the province of Ontario. The estimated average annual value in Canada for the period 1916—20 was dollar 43,036,000 upon a planting of 695,197 acres. Most of this acreage is in the provinces of Ontario and Quebec. The crop has an estimated value of dollar 33,925,680 and an acreage of 544,580 acres in Ontario and a value of dollar 6,768,940 and an acreage of 116,120 acres in Quebec. Corn for husking or grain as a commercial and feed crop is grown chiefly in Ontario upon 197,045 acres with an estimated annual value of dollar 14,403,880. The major acreage is planted to so-called fodder corn, there being 348,535 acres with an estimated value of dollar 19,521,800 in Ontario and 69,446 acres with an estimated value of dollar 4,236,740 in Quebec. The fodder corn, though not marketed as corn, is a most important feed crop and the cornerstone of the dairy industry in Eastern Canada.

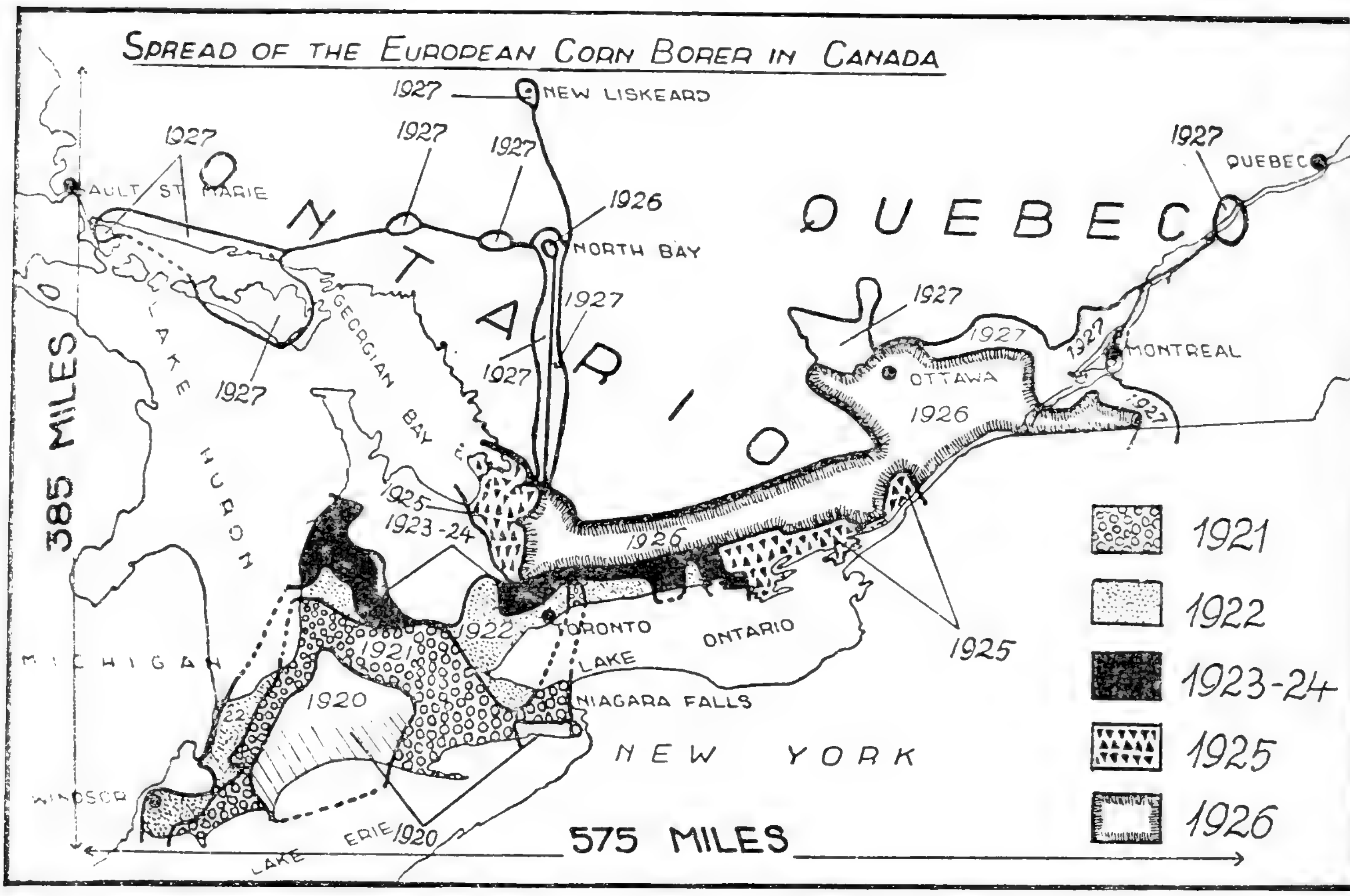
is indicated on the accompanying sketch map (p. 140). The territory occupied by the insect has increased at an average annual rate of 4200 square miles, with the result that during the eight years under observation it is known to have spread to and to be present in 32,000 square miles of agricultural country in the provinces of Ontario and Quebec. Owing to the peculiar distribution of the arable land and unsettled parts of the country the distribution of the insect has necessitated the establishment of a quarantine zone involving an area of 165,000 square miles. Thus, at the present time the infested zone embraces the entire corn-growing area in Ontario and a great proportion of that in Quebec.

The rate of natural distribution, though steadily outward into new territory, has varied from year to year. The spread has been so greatly conditioned, by the peculiar distribution of the corn crop, the arable land, the prevailing winds and the waterways, that any natural tendency in distribution, is almost impossible of determination. At the present time in Ontario and in so-far-as the major infestation extends in Quebec, the map of the distribution of the borer is virtually a map of the area in which corn is grown, and incidentally of the arable land at present under the plow. The northern and far western isolated occurrences have not been the result of natural spread, but have been due undoubtedly to larvae transported in infested corn, in spite of the quarantine, having established infestations in the kitchen gardens of the settlements along the transcontinental railways. The area adjacent to, but at present not included in the infested zone, is rough and broken forest land with little or no agriculture of consequence and no real corn-growing.

Paralleling the distribution of the insect, there has been a continuous and rapid increase in numbers from year to year, as the borer became established in the various localities. The rate of increase varied, however, from locality to locality, and was very rapid in a zone of from 10 to 20 miles wide along the shores of lakes Erie and Ontario; the most spectacular increases in this zone, however, being in the three counties in the extreme southwest (text-fig., p. 140). In general, the increase was most rapid in the areas of greatest grain corn concentration, as for example, in Essex county, the most southwesterly corner of the infested area, where a stalk infestation of 1.3% in 1923 increased in 1924 to 13.5%, in 1925 to 37.5% and in 1926 to 83 %. The rate was somewhat less marked though very rapid in areas in which much corn was grown for canning purposes, as in Prince Edward county, along the lake Ontario shore, where an infestation of 1.9% in 1926 rose to 14.9% in 1927 in the areas under study. In the fodder corn areas on the other hand the increase, though steady, has been much less rapid, as illustrated by Middlesex county, somewhat further inland incidentally, where the infestation increased from 6.43% in 1924 to 9.7% in 1925, to 28.5% in 1926 and to 43.8% in 1927.

It should be noted here that the average per cent of stalks infested in an area, used above, is really a poor indication of the relative intensity of infestation in any one field or group of fields after it exceeds 50%. This is accounted for by the fact that between this degree of intensity and 100 % stalk infestation the number of borers per stalk rises more rapidly than the per cent of stalks infested. A 100% stalk infestation, and hundreds of such fields were present in several counties in 1925 and

1926, thus may represent in our figures an average population per stalk of anything from 5 to 39 mature borers at harvest time. Adequate population counts were impossible under our circumstances and stalk infestation counts only could be made. They give, however, a fair guide to the situation up to the time when severe economic losses begin to be felt, after which the increasing destruction of the crop demonstrates only too clearly the further upward trend of the population.



Sketch map of the spread of the European corn borer in Canada from 1920—1927. The diagonal lines indicate the area of severe infestation.

Economic History in Canada.

In considering the economic history of this insect in Canada, it should be borne in mind that its normal life-history is passed only upon corn of various kinds and sorghums, that is normally has but one generation per annum, and that though it has been recovered from 57 other species of plants, upon none of them has it been known to live from year to year. It lives upon dent, flint and sweet corn with equal readiness and if present in sufficient abundance destroys them with equal thoroughness. Apparent varietal immunity, at the present time, depends upon some other factor, such as delayed development in the season or physical resistance to collapse. Dent and fodder corn resist attack better than the flint and sweet varieties because of their greater bulk, and sweet corns of slim stalk followed by flint corn of a similar type suffer the first economic damage in a locality due to their physical limitations apart entirely from possible earlier planting.

The effect of the presence of the borer was beginning to be felt in individual fields and sweet corn patches the year of its first recorded

presence, in a small district in the centre of the southern half of the larger infestation, near the city of St. Thomas some five miles from lake Erie. Much of the early sweet corn was even then unmarketable and several grain corn fields had from 90 to 100% of the stalks infested. The losses, however, in field corn did not exceed ten per cent for all purposes as regards grain corn and was negligible in the fodder corn, though this also was severely infested. In 1921, the area of measurable loss extended to include a territory about 10 miles east and west and 8 miles north and south and the severity of injury to the crop increased strikingly. Many fields of flint corn had every stalk infested and losses of at least 30% of value as fodder, and 70% as a commercial crop were frequently encountered in grain corn. In addition, the early market and mid-season sweet corn throughout the area was ruined as a marketable crop. During 1922 the zone of severe damage upon the scale of that of 1921 extended somewhat north-east, but chiefly westward along the lake shore counties and into the strictly grain corn areas.

During 1923 the area of severe infestation extended still further westward, with the numbers of borers increasing though with decreasing actual losses, as the corn grown for grain changed from the flint to the dent varieties, which are grown almost exclusively in the western counties. During 1922 and 1923 the borer population had built up to a point where it could thoroughly devastate dent corn fields, and in 1924 began the economic evidence of this spectacular increase in borers in the southern half of the isthmus of the southwestern peninsula. Thus in this year the bulk of the grain corn crop in an area of 20 square miles in this locality was so severely injured as to be of no commercial value whatever and much of it practically worthless as fodder. So severe were the losses that relatively no corn was planted in the area the following year. This general locality, however, served as the centre and focus of a severity of loss vastly more serious than the older eastern one. In 1925, the area of virtually complete loss of crop increased to involve at least 400 square miles, with serious losses radiating outward in all directions in decreasing severity for from 10 to 20 miles. In 1926 the crop upon at least 1200 square miles was virtually ruined for any purpose whatever and losses of ruinous severity were being suffered throughout the two counties of Essex and Kent and the southern half of the county of Lambton. The whole grain corn industry was brought to a condition of complete disorganization and the agricultural situation was one of the utmost seriousness. The financial loss in these three counties would be impossible to calculate, but the total acreage in field corn compared with the average in this crop between the years 1919 and 1924, decreased between the years 1924 and 1927 from 187,200 acres to 64,174 or by about 66% and the acreage of grain corn from 151,860 acres to 41,293 or by about 73%. The acreage of grain corn has also been decreased somewhat in three adjacent counties, but in much smaller proportions.

The practical ruin of the grain corn industry was accompanied throughout the area of severe infestation by a most serious interruption in the satisfactory growing of table and canning corn. Early and mid-season sweet corn for commercial purposes was virtually abandoned for any but

local markets where the ears could be stripped and culled in the presence of the purchaser. The canning of corn has also become troublesome.

The fodder corn losses have nowhere compared in severity with those of the grain corn. The increase in infestation in the areas where this type of corn predominates, was at a much slower rate for a variety of reasons, and where it was grown in association with grain corn, the latter usually bore the brunt of the attack due to its average earlier date of seeding. Thus due to the slower rate of increase of the insect in this type of corn and the greater ease of applying control measures due to the farming practices and the smaller individual acreages, such staggering losses have not been and are not likely to be suffered. Had control activities not been undertaken, however, there is little doubt but that eventually even the fodder corn, over the greater part of Ontario at least, would have gradually become impossible of economic culture.

The discussion has dealt chiefly with the conditions in the south-west corner of the infested zone. Throughout the northern half of the area infested in 1920 the rate of increase has been relatively slow and though infestations are fairly high and increasing, little real loss has yet been suffered except in sweet corn. The conditions are somewhat similar in the zone of infestation of 1921 and 1922 with the greatest increase being in the lake shore areas. No real loss has been sustained in the areas of spread of 1923, 1924 and 1925 except in Prince Edward county along lake Ontario, infested in 1925, where the canning sweet corn is beginning to show the attack upon the ears. The areas found infested in 1926 and 1927, in general, still have a borer population so sparse as to make its presence little more than a matter of record and a potential menace.

The Progress of the Control Problem in Canada.

The general threat to the corn crop of Canada was vaguely realized upon the discovery of the insect within our corn area, and events soon indicated how very serious was that threat in Canada, as well as in the United States. Investigations were initiated in the autumn of 1920 by both the entomological services of the Dominion of Canada and the province of Ontario and carried on with a hectic rush only exceeded by the phenominal spread of the insect and the almost unbelievable increase in abundance and severity of damage. By the end of 1922 a sketch of the life-history, habits and certain reactions of the insect in relation to farm practices, indicated that the destruction of the part of the crop not utilized for feed, since known as the "clean-up", was the most promising means readily available to the farmer for holding the borer in check. This "clean-up" was simply the destruction of the corn crop remnant, — stalk, stubble and refuse —, of one year before the flight period of the insect in the succeeding year, either by ploughing under cleanly and permanently, or by burning.

From the time of the discovery of the pest in Canada the most intense publicity was given to the fact of the presence of the insect, its latent menace, and as time went on, to its rapid spread, its speed of increase, the actual devastation in the crop itself and the suggested means of control. Events succeeded each other with such rapidity, notice of its occurrence in the district was followed so promptly by the obvious pre-

sence of the insect and this by the ruthless destruction of the crop, particularly in the grain corn areas, that the farmer with a feeling of absolute helplessness proved unwilling and unable to shoulder the control responsibilities upon a voluntary basis and insisted upon control activities under legislative authority.

Legislation for the control of the European corn borer was enacted in 1926 by the Government of the Province of Ontario and is being enforced under the direction of the Provincial Entomologist. The legislation, in essence, requires the ploughing under of all corn stubble and field refuse and the hand burial or burning of all corn crop remnants not ploughed under, before the flight period of the moths, in any year.

The enforcement of the control in Ontario was undertaken in the fall of 1926 in the eight most severely infested counties, and the crop of 1927 was grown under the first widespread attempt at control in Canada. Of the eight counties involved, five, the most severely infested in the province, are reported by the Provincial Entomologist to have shown reductions in infestation of from 20 to 50%. The reduction in infestation and crop damage was greatest in the two most severely infested counties of Essex and Kent. In the other three counties, those less infested, the borer again increased. That the striking reductions in infestation were entirely due to the control practice is not asserted without qualification, and other factors may have helped, yet there is little doubt but that the control activities must have been a most important influence.

The compulsory control was extended in 1927 to include 22 counties, and the outcome is awaited with the most lively interest. The quality of "clean-up" in preparation for the 1928 crop was excellent in most counties, and the results for the year should clearly indicate the possibilities of this form of control for the future.

In addition to the field control activities, the territory infested has been retained under a series of quarantines regulating the movement of corn and corn products, designed to reduce the danger of establishing new infestations in advance of its natural rate of spread. This restriction upon the distribution of infested material has undoubtedly played a large part in preventing the establishment of isolated areas of infestation in the earlier years of the outbreak and thereby has delayed by years the time when many localities suffered serious losses.

That every available pressure might be brought to bear upon the insect, biological control by means of imported parasites has been most actively promoted. The work in this field has been and is being carried on in closest cooperation with the United States Bureau of Entomology. Six insect parasites *) imported from Europe have been reared in quantity and liberated throughout the area of infestation to an approximate number of three million during the last five years. Three of these parasites **) have already shown their ability to survive our winters in the open, and it is hoped that further liberations of other species will eventually prove

---

*) *Exeristes roborator* Fab., *Microbacon brevicornis* Wesm., *Microgaster tibialis* Nees, *Apanteles thompsoni* Lyle, *Macrocentrus abdominalis* Fab., *Eulimneria crassifemur* Thoms.

**) *Exeristes roborator* Fab., *Microgaster tibialis* Nees, *Macrocentrus abdominalis* Fab.

several of them to be capable of establishing themselves as effective parasites of their old host under the new conditions.

The direct investigation of the insect itself, in its relation to crop and climate, must of necessity continue. A host of problems requires solution even assuming that our most optimistic hopes for the "clean-up" method of control is justified. A more direct, simple and less burdensome control than the present one must be found, if possible, to release the restriction upon the acreage which the present practice implies. Methods of protecting varieties of corn liable to great loss when grown in areas where the main crop can withstand a high concentration of the insect, must be devised; an analysis of climatic conditions making for violent increase must be made, and even such an apparently simple matter as the determination of the best method of ploughing corn stubble with farm tools, in order to keep it permanently below ground, has yet to be solved for various soils.

Before closing I would like to call attention to the exceedingly complete cooperation existing between the Canadian and United States entomological services in the prosecution of the various activities associated with the European corn borer problem. I say cooperation, but in reality a great professional and personal indebtedness has been assumed upon our part. Free access to the Unitcal States laboratories, methods of study, field technique and data has always been accorded us with a generosity that has been an inspiration. The foundation material for our imported parasite liberations has been secured through the United States Bureau of Entomology as a gift outright, and our only regret has been our inability to reciprocate with something more tangible than a high regard and a professional admiration.

The Characteristics and Uses of Petroleum Oil Sprays.

E. R. de Ong, San Francisco, California.

(With one text-figure.)

The entomologist has for fifty years recognized the value of petroleum oil as a cheap, efficient and widely distributed insecticide, but one that could be used on trees only with caution. Kerosene is fairly safe on Citrus trees, but too volatile for effective scale insect control. The heavier unrefined distillates, as well as crude oil, are dangerous to foliage, and sometimes injured even dormant deciduous trees. The occasional reports of injury that occurred, both to dormant trees and those in foliage, were sufficient to retard the general use of oils in combating the insect pests of plants. Consequently the entomologist lost the use of one of our most valuable insecticides, for petroleum oil is useful not alone for its insecticidal value, but also for its physical qualities and as a carrier for other toxic chemicals.

A new and rapidly expanding era in the use of oils on plants has come in recent years with the discovery of the correlation between plant tolerance and the concentration of unsaturated hydrocarbons, aromatics, olefins, and other bodies, commonly present in oil, but removed by the use of sulfuric acid or liquid sulfur dioxide.*) This impetus to the consumption of oils for spraying purposes has been so great as to stimulate interest in this new field among all the oil-refining companies. Many of the larger oil companies of the Pacific Coast and the Eastern States are now studying this field and are eager to cooperate in the development and selection of oils best adapted to the purposes of both the entomologist and the horticulturist. Further expansion in the consumption of oil as a tree or animal spray, or even maintainance in the fields now occupied is, however, conditioned upon an ever better knowledge of the various fractions used for this purpose, both from the standpoint of their insecticidal value and their reaction to the plant.

1. Should the use of spray oil be restricted or expanded?

It is a common mistake in the distribution of any product that claims for efficiency are sometimes made which cannot be substantiated, — at least in that immediate stage of development. Oils for use in the orchard are not an exception. During the past five years there have been occasions where the recommendations, by trained entomologists and horticulturists,

*) Gray, Geo. P., & E. R. de Ong, Laboratory and field tests of California petroleum insecticides; in Indus. Eng. Chem. (1925) 18: 175—180.

of oils for the control of certain insects, have not been justified. Many have felt that the attempted control of codling moth with oil instead of arsenate of lead was a mistake. But on the other hand, there is much evidence to support the use of an oil spray as a supplement to the regular arsenate of lead applications, provided an oil safe for general purposes is furnished. The California Citrus grower has had many difficulties in the way of prematurely dropped fruit and imperfect coloring from the use of oil, yet much of this difficulty has already been eliminated simply by the use of less viscous and more volatile oils. Since oil sprays have been generally used, districts in which scale insects resistant to hydrocyanic acid gas had developed, are now cleaner than they have been for years. Again the combination of oil with the established insecticide gives better promise than either used alone. Many other similar instances could be cited in which the first recommendations in the use of oil sprays have not given the expected results, but further study of the problem has developed a successful practice.

2. Petroleum-nicotine combinations.

Petroleum oil has the natural advantages of low surface tension, penetration and wax solvency that make it superior to water as a carrier for other and more active insecticides. Hence even though oil may lose insecticidal value by the refinement necessary to give plant tolerance, it retains the advantages of its physical qualities, and may, in combination with nicotine and pine oil or other toxic materials, have a higher toxicity than it did originally. A distinct advantage in the oil-nicotine combinations, tested against the brown apricot scale (*Lecanium corni* Bouché), was that of the uniformly high toxicity secured, irrespective of the viscosity and volatility of the oil. Kerosene and the very lightest of lubricating oils, at a 2% concentration of oil and 0.01 to 0.02% concentration of free nicotine *) in the diluted spray gave a similar toxicity to that of oils of a viscosity of 85 to 110 second Saybolt.

Kerosene without the nicotine showed but little better kill than that of the untreated check. The nicotine-oil combinations thus offer possibilities in the use of cheaper oils, which, on account of their volatility, would also be safer to use on plants. The slight extra cost of the nicotine would be largely met in the saving of the cost of the oil. As a basis for the comparison of the concentrations of nicotine used alone and with oil it should be noted that the usual concentration of nicotine alone in the spray tank is 0.05%, with the cost of a spreader in addition, while the range of nicotine concentration in the oil combination is usually from 0.01 to 0.02% with the oil acting as a spreader. For insects very difficult to control slightly higher dosages of nicotine may be found advantageous.

Certain fractions of pine oil have been found useful in combination with petroleum oil and offer the advantages of an increased fungicidal and insecticidal action, particularly with very highly refined oils (98—100% unsulfonatable) also an increased solvency for nicotine over that of

*) In all combinations of oil and nicotine it should be noted that the uncombined or "free" form, 95% concentration, is used and not nicotine sulfate.

petroleum oil. The latter does not readily dissolve free nicotine of the 95% commercial from, because it contains water, and hence petroleum-nicotine mixtures, when emulsified, have the tendency to lose the nicotine to the water and in "quick breaking" emulsions the nicotine would then be largely lost in the "run-off" of water. Nicotine-water solutions do not penetrate the tracheae of insects and hence kill principally by a fumigating action. Nicotine disolved in certain pine-oil fractions forms a true solution, and thus the greater part remains in the oil and may penetrate directly into the tracheae of the insect.

Recent developments in the study of oil-nicotine combinations have shown that nicotine apparently has a tendency to minimize certain of the difficulties in the use of oil on foliage. This requires further confirmation, but in the work to date it has been found in a number of instances that the oil-nicotine combination interfered less with the functioning of the leaf than did the same oils used alone.

3. Physiological reactions of oil on the Plant.

A complete understanding of the effect of oil on the living plant must take into account physiological reactions, for this constitutes the principal action noted after applying the present type of oil sprays. By physiological reactions is meant the disturbance of normal functioning, including transpiration of water, respiration or interchange of gases, and photosynthesis or the manufacture of sugar and starch. In contrast with these relatively minor effects, the results from the use of less highly refined oils include severe defoliation, marring the fruit, and killing the bearing wood.*)

The results from such physiological reactions are varied and may be either beneficial or harmful according to the condition of the plant, time of application, type of oil used and manner of application. It has already been shown that the blooming dates of certain trees may be advanced or retarded as desired. There is also proof of an increased resistance to wind dessication of oil-sprayed trees over fumigated ones. Oiled wrapping paper is used to retard the transpiration of water from stored fruits. Dark green, luxuriant foliage is frequently noted in oil sprayed trees in contrast with untreated trees or those sprayed with other chemicals. Such a stimulation is apparently not due to an increased supply of readily available food, but is a secondary result of the efforts of the plant to throw off the oil, analagous to the use of strychnin as a stimulant in the human system.

Such stimulation may be beneficial, if the safer types of oil are used and at a time when the tree is not subject to a heavy draft on its stored starch, e. g., when setting or maturing a crop of fruit. Certain of our fruit growers are talking of an increased set of fruit resulting from spraying at definite times in the dormant season. One pear grower is planning an oil-spray program in the attempt to change his harvest time to a more profitable season. These incidents are sufficient to show that there are possi-

*) de Ong, E. R. Technical Aspects of Petroleum oil. In Jour. Econ. Ent. 19: 733—745.

bilities in the use of oil on plants in addition to that of its insecticidal action.

The solving of such problems will require the cooperation of the plant physiologist. A number of them are now working on the problems in cooperation with the entomologists. Knight*) has shown that there is a temporary decrease in transpiration, an increase in respiration and decreased photosynthesis in oil-saturated foliage.

The author has been able, through the efforts of laboratory assistants, particularly Mrs. Margaret V. B. Smith, to show in experiments with unemulsified oils that these penetrate readily through the opened stomata of the leaf and in a few hours, or days at the most, the oil will be distributed through the cellular structure of the entire leaf. In the course of days or wecks, owing to the type of oil used, and probably also to ecological reactions, this oil gradually disappears. The removal of the oil from the leaf is apparently due in part to volatilization, breaking down of the oil and translocation, for it may readily be seen in the form of small globules in the vascular bundles or water carrying tubes of the leaf. While the leaf is saturated with oil, little or no starch is formed, normal functioning being restored with the disappearance of the oil. The use of emulsified oils at low concentrations minimizes the above physiological reactions, which were obtained with undiluted oils.

The inhibition of starch formation is not a serious matter, provided it is not too prolonged. No starch is formed during the night and little, if any, in dark cloudy or fogy weather. Hence it would seem that the possible danger resulting from the interference with normal functioning might be overcome by a wisely planned spraying program and further studies in the choice of oils. The Citrus growers of Southern California have already encountered this problem and to a large extent solved it for their own needs. Other problems can be studied in the light of this knowledge.

4. Specifications for spray oils.

The entomologist, by his adoption of petroleum oil in his war against insects, has developed a peculiar and very discriminating need for oils suited to his work. Such oils must be defined in exact technical terms and ones which are largely different from the specifications for the lubricating oil trade. We need the cooperation of the oil chemists and their laboratories. But to justify such cooperation we must be able to show that there is sufficient demand to justify spending large amounts of time and money. Now that this volume is being reached in some districts, we can ask for oils refined for our purposes and according to specifications that are generally uniform, as rapidly as these are perfected. The discussion of specifications that follows is divided into two groups: (A) those commonly used in the lubricating oil trade and not necessarily of great significance for spray oil; (B) new or modified specifications especially significant for evaluating oil for use on plants.

Group (A).

Specific Gravity (commonly expressed in degrees Baume or in late technical paperes as A. P. I.). — The density or specific gravity of an oil is

*) Knight, Hugh. Unpublished manuscript.

used principially to distinguish between the volatile kerosenes and the relatively slow-evaporating lubricating oils. However, gravity of oils varies widely and often with little relation to volatility, viscosity, and other characteristics. Its chief value lies in separating oils according to the territory in which they originate. Until much more information is available concerning the merits of oils from different fields, it can be of little interest in the evaluation of spray oils.

Flash Point. — The flash point is the minimum temperature to which an oil must be heated to give off inflammable vapors in sufficient quantity to produce a combustible mixture. This test is of value in determining the safety of kerosenes and lubricating oils from the standpoint of fire, but is of little importance in spray oils.

Fire Point. — The minimum temperature at which burning persists after ignition occurs.

Color. — The varying shades and tints commonly manifested by petroleum-oil fractions may result from the presence of minute particles of asphalt, solidified waxes, carbon, and other matter suspended in the oil, or from true solutions of colored compounds, such as nitrogen bodies or unsaturated groupings containing chromophores. These suspensoids, and to a large extent the unsaturated hydrocarbons, may be removed by filtration through certain hydrosilicates, e. g. bentonite. The physical process of filtration alone, however, does not completely separate the unsaturated from the saturated hydrocarbons, which, as explained later, is the chief basis for distinguishing between the groups tolerated by the plant and those which are not. Color alone must be considered either of doubtful significance or deceptive.

Sulfur. — Sulfur, unless in the organic form, is considered a hazard to the plant. Elemental sulfur is injurious even in very small amounts, further work being required to determine the exact quantity. However, the usual refinery practice necessary to raise the unsulfonated residue to a satisfactory point reduces the sulfur to a negligible point in most instances.

Distillation. — Distillation separates an oil into fractions of varying boiling points, and is often used as an indicator of volatility, it being very intimately associated with this characteristic. Since distillation begins between 150° and 300° C. and ranges as high as 325° C (at which time decomposition or cracking begins), it does not seem greatly significant in field work except as an indicator of the proportions of more or less volatile oils. Another method for determining volatility more in accordance with the field temperatures is suggested under the heading "Volatility". In the absence of volatility specification the distillation test is desirable. It is, however, less satisfactory than the volatility test, because of a varying increase in vapor pressure of oils from different sources with increases in temperature, and because of "cracking", which occurs at 325° C and above.

Group (B).

Acidity. — Unrefined petroleum oil usually contains small amounts of organic acids. Highly refined spray oils should not contain an appreciable degree of acidity. It will be found, however, under the heading "Oxidation", that the acidity value is not a constant factor. Oils to be used for foliage

application should be practically neutral, from the chemical standpoint, at the time of application. Those for dormant application should not contain more than a very small fraction of 1% of acid.

Volatility. — The rate of volatilization of oils is an important factor closely associated with viscosity. Much of the value as well as the difficulties attending oil sprays are associated with these two characteristics. Volatility is the principal difference between kerosene and lubricating oils. The former is ineffective against most insect eggs and resistant scale insects. Lubricating oil persists in the form of a film on the leaf surface or in intercellular spaces for weeks or even months, acting as a repellant or a toxic agent during this time. The following method for determining the volatility of oils to be used for spraying is suggested as being of greater significance than the distillation range and more nearly comparable to the conditions existing in oil-soaked plant tissue, — the inner structure of asbestos paper offering an immense surface similar to that of the internal structure of the leaf. This test has been devised in cooperation with the Shell Oil Company. The test consists in determining the rate of evaporation of the oil sample from a standard grade of asbestos paper suspended in an oven kept at a controlled temperature, ranging from 50° to 100° C, according to the oil fraction used. A weighed amount, ± 0.5 gm., of oil is placed on a sheet of the asbestos paper, three inches square, and weighings made at regular intervals from one to four days apart according to volatility. Thermostatic control of the temperature is necessary, as is also a small current of air flowing thru the oven. Oil samples that vary widely in their volatility should not be in the oven at the same time.

Viscosity. — This property is expressed as the rate of flow thru a definite orifice at a standard temperature. Viscosity is frequently used as an indicator for volatility, but these two characters should not be confused, as their attributes are not uniform. Oils from a similar source and with the same distillation history will have a uniform viscosity, but during the refining process, using sulfuric acid, the viscosity often changes enormously, while the volatility and flash point may change but slightly. — It should also be noted that the viscosity of an oil changes greatly during the ordinary changes of temperature found in field practice. An oil having a viscosity of 100 seconds on the Saybolt viscosimeter at 100° F may have a viscosity of 75 seconds at 120° F, and 250 seconds at 65° F. Such a range of viscosity implies a similar variation in penetration and spreading qualities and may explain some of the vagaries of oil applications in the field.

Viscosity is a valuable characteristic from the standpoint both of evaporation and penetration. The latter factor applies both to penetration into the tracheae of the insect and entrance into the leaf and twig. Oils of the kerosene type are known to pass rapidly through the entire tracheal system of an insect and may in this way carry other and more active insecticides.*)

---

*) de Ong, E. R., Hugh Knight., and J. C. Camberlain: A preliminary study of petroleum oil. an insecticide for citrus trees; in Hilgardia (Calif. Agr. Exper. Stat.) 2: 351—384 (1927).

Viscous oils of 100 second Saybolt penetrate the tracheal system very slowly. They are, however, fixed so firmly that they cannot be dislodged, probably causing such a degree of suffocation as to contribute to the death of the insect. The viscous oil is also difficult to remove from the leaf, once it has entered, thus leading to functional disturbances and, possibly through oxidation, to acute injury.

The present trend in spray practice in Southern California is strongly towards oils of viscosities of 50—95 seconds Saybolt at 100° F, the lighter ones being for the black scale and the heavier for the red scale and red spider, and also for use on deciduous trees. The report of R. S. Woglum, Entomologist for the California Fruit Exchange, shows for the year ending June, 1927, that non-coloring of fruit and non-setting of bloom was practically eliminated the past year (June, 1926—June, 1927) with the general use of light oils. For the corresponding period ending June, 1926, the work was mostly with an oil of 100 to 110 seconds Saybolt viscosity and serious difficulties were encountered, especially when applied in the fall.

Oxidation. — The saturated hydrocarbons, which are almost the only constituents of the highly refined white oils, are not active chemically, but when exposed in thin films to the action of oxygen and sunlight, they undergo a chemical change, and an increase in acidity can be shown. The Sligh*) method of determining the degree of oxidation in lubricating oil has been the basis of testing oils for use on plants. The method has been modified to this extent that the degree of oxidation is measured by the amount of acidity developed rather than the measurement of a sludge precipitate.

In cooperative work with the Shell Oil Company, it has been found that injury to foliage is correlated with the degree of acidity with oils oxidized in the above way.

Experimental work has shown that the chemical reaction commonly expressed as "oxidation" may be one of extreme importance in evaluating oils to be used for spraying. Oils rated highly from the standpoint of safety may, upon exposure for a few hours or days to certain factors, become highly dangerous to foliage. Experimental work on the significance of oxidation in defining oils for spraying purposes is as yet incomplete, for it has been carried on less than a year, and much time will be required to perfect all the details.

Unsulfonatable Residue (also expressed as the "Sulfonation Test" and the "Proportion of Saturated and Unsaturated Hydrocarbons"**). — There are two large classes or groups of compounds found in petroleum oil: (1) the saturated hydrocarbons, naphthenes and paraffins, which are largely inert chemically, and (2) the unsaturated hydrocarbons including the aromatic series and the olefins. The latter group is more active chemically, having greater possibilities of reacting with oxygen and other chemicals.

---

*) Sligh, J. T. S. an oxidation method for measuring the stability of mineral oils, 1924; in Proc. Amer. Soc. Test Materials, Vol. 24, pt. II.

**) An arbitrary grouping of the hydrocarbon series has been made in conformity with the original paper (1) on this subject. The hydrocarbon series, naphthenes and paraffins, are spoken of as "saturated hydrocarbons" and the olefins and aromatics series are grouped together under the term of "unsaturates and aromatics".

From the nature of the two groups it is apparent that the second would probably be the more effective as an insecticide by reason of its power of solubility and possibly the chemical activity. These deductions have been shown experimentally to be correct, but the very factors which are valuable from the insecticidal standpoint are a detriment from the standpoint of plant tolerance. Hence it becomes necessary to rely principally on the group of chemically inert fractions as the basis for spraying oils. Recognition of the necessity for separating these two groups of distillates was first made by Gray and de Ong*) in joint work done in 1914 and 1916, but not printed until 1926. The development of this principle formed the basis for the present enormous expansion in the use of refined petroleum as an insecticide for use on plants.

This character is probably the most important one of all the specifications used in the defining of oil suitable for such work; it should be noted, however, that it cannot be used alone as the sole guide in choosing insecticidal oils. The sulfonation test when used in connection with other characters, including oxidation, volatility, and viscosity, gives an accuracy of evaluation that is very useful and one that can be applied wherever trained workers are available.

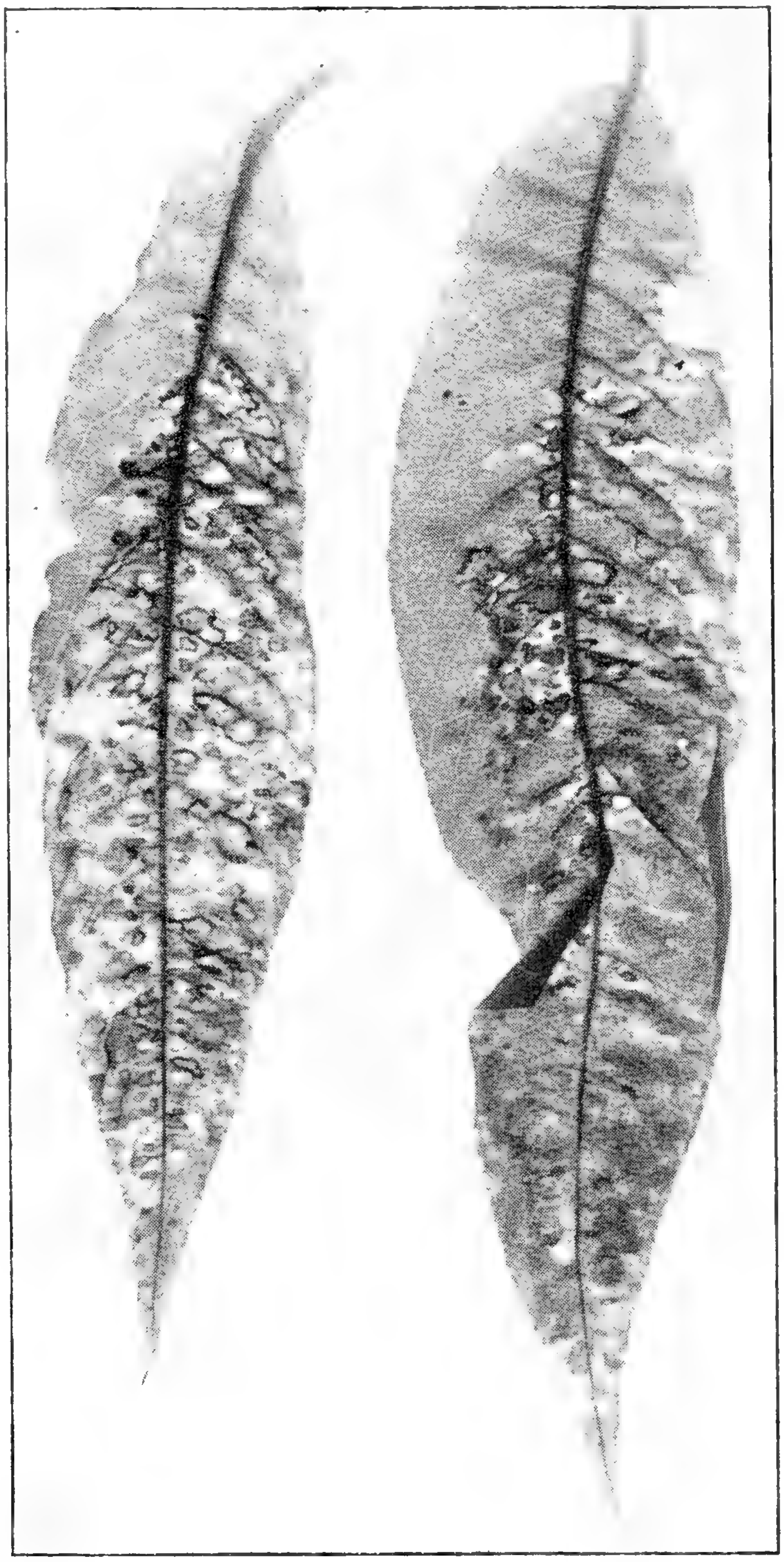
The use of the last group of specifications for evaluating oils will, it is believed, form the basis for laboratory standards that can be used anywhere as a guide in selecting oils for spraying purposes. The methods for determining volatility and oxidation are still in the formative stage, while those for viscosity and sulfonation are already standard. The following procedure for determining the unsulfonatable residue is the official method as adopted by the Division of Chemistry, California State Department of Agriculture: "Determine the specific gravity of oil at 25° C. (77° F.) and weigh the equivalent of 5 cc. into a Babcock cream bottle (or A. S. T. M. sulfonation bottle). Add slowly 20 cc. of exactly 37 N. sulfuric acid in four equal portions, shaking after each addition and taking care that the temperature of the mixture does not rise above 100° C. (212° F.) by cooling in ice water if necessary. When the mixture no longer warms on shaking, agitate thoroughly, immerse the bottle in a water bath at 100° C. (212° F.) and hold at this temperature for one hour, shaking every ten minutes. Fill the flask with strong sulfuric acid (approximately 1.84 specific gravity) until the oil rises into the graduated neck, centrifuge to constant volume of the oil approximately 1500 revolutions per minute, cool to 25° C. (77° F.) and read the volume of the unsulfonated residue from the graduations on the neck of the flask, and calculate the per cent by volume".

5. Recommendations for Foliage and Dormant Sprays.

The following suggestions regarding the application of oil is given as a summary of the above remarks with a full recognition of their limita-

*) Cf. footnote p. 145.

tions, but with the hope that they may act as a guide in the choice and use of spray oils.



Peach leaves treated with oil oxidized by heating to 150° C for three hours in an oxygen atmosphere. Check treated with unoxidized oil was normal.

Foliage or Summer Spray. — Oils with an unsulfonatable residue of 88 to 99%, i. e., the proportion of oil which will not react with sulfuric acid, are usually the safest. The higher percentage of unsulfonatable residues are not quite as active as insecticides as are the lower ones, but this type of oil is usually safer to use on foliage. The value of a high unsulfonatable residue should, however, be taken into consideration with the oxidation rate. Generally speaking, it is probably safer to use the lower grades of unsulfonatable values in very volatile oils, than with less volatile ones. The former are, of course, cheaper than the more highly

refined fractions, but a difference of a few cents a gallon in the cost should not be allowed to influence the choice when at the same time safety is to be considered.

The viscosity range at 100° F varies between 40 and 110 seconds Saybolt. The choice is dependant upon the species of insect concerned, the time of year, and the stage of development of the tree. Newly hatched Black Scale *(Saissetia oleae)* are very susceptible to oil and may be controlled with the less viscous forms. The Red Scale *(Chrysomphalus aurantii)* is more difficult to control and requires the most viscous, non-volatile oil the tree will bear. A viscosity of 50 seconds Saybolt has been found the lowest limit, giving a 100% kill of the Red Scale; hence the range should be between 50 and 100 seconds for this insect, with the higher point used only with a full recognition of its greater danger to normal plant functioning.

The concentrations of oil in the diluted emulsion, for these two scales, ranges from 0.8 of one percent to 2.0% of oil.

For Red Spider *(Paratetranychus* and *Tetranychus* spp.) a viscosity of 50 to 90 seconds Saybolt is favored and should be applied a few weeks before the ripening season of the fruit.

No definite standards have been established for oxidation values and volatility, but choice should always be given to the most stable type of oil, i. e., one that shows the least tendency to oxidation. The more volatile oils are usually considered safer than those of a less volatile type, but much more work remains to be done on this factor.

Spraying of Dormant Deciduous Trees. — This should be done as near as possible to the time of the greatest degree of dormancy. Spraying just after the leaves drop in the fall or after the buds are swelling and bursting in the spring is always attended with greater danger.

Preference should be given to oils containing 65 to 75% unsulfonatable residues. Those of a value between 48 and 60% should be used with great care, if at all. The viscosity at 100° F may range from 65 to 150 seconds Saybolt and above, laboratory standard, remembering that the viscosity varies greatly at lower temperatures. At temperatures ranging from 45 to 65° F in the field a viscosity of 80 seconds Saybolt has given better control on the brown Apricot Scale *(Lecanium corni)* than those of 60—70 seconds or 100 seconds and above. The higher viscosities are used on the armored scale insects and for the leaf-roller eggs.

Concentration of oil varies from 2 to 6%, the former being the strength commonly used on young Unarmored Scale insects and Red Spider eggs *(Bryobia* sp. and *Paratetranychus).*

Spraying should not be done when the tree is suffering from lack of moisture, nor at temperatures of 70° F or above.

The nicotine-oil experiments are stressed as an example of oil combinations with other chemicals which may prove valuable in the variety of problems in pest control.

Developments in the Fumigation of Citrus Trees.

Professor H. J. Quayle, California Agric. Experiment Station, Reverside, Cala.

The fumigation of trees in orchard form is practically limited to Citrus trees. The Citrus tree, on account of its compact growth, its not too large size, the fact that it is an evergreen, and that the chief pests are the comparatively resistant coccids, make it well adapted to coverage by a tent and the liberation of a gas within, or rather, that these conditions make the Citrus tree less well adapted to spraying. The continuous presence of dense foliage makes a thorough application of a spray difficult and also limits the use of materials in concentrated form which are necessary to kill such insects as scale insects.

Early History.

The first attempt to fumigate trees and plants outside of greenhouses was made by James Hatch, of Lynn, Mass., in 1867. In May of that year Mr. Hatch secured a patent that related "particularly to the manner of effecting the destruction of insects known as canker worms by covering the entire head of the tree with a thin cloth of close texture and drawing the edges around the trunk so as to envelop the branches in a sort of sack". Nearby was a furnace where tobacco, pepper or other substances were heated and the smoke thus formed conducted into the tent by means of a pipe.

When the cottony cushion scale, *Icerya purchasi* Mask., became established in the Citrus orchards of Southern California in the early 80's and the sprays then in use failed to control it, fumigants liberated under a tent were tried. Wolfskill and Craw among others experimented with dry heat, steam, tobacco smoke, muriatic acid gas, carbonic acid gas, chloroform, arsenic, alcohol and carbon disulphide. Coquillett *), an agent of the Division of Entomology prior to July 1st 1886 and after July 1st 1887, joined these experimenters in September 1886 and soon determined that hydrocyanic acid was the most satisfactory material thus far tried. Secrecy, as reported by Riley **), surrounded the original work with cyanide, since an effort was made to secure a patent on the process, but this was already covered by the Hatch patent. The consequent delay prompted certain growers to ask the University for a chemist, and in April 1887 Morse, of the California Experiment Station, began an investigation

*) Coquillet, D. W., in U. S. D. A. Rept. pp. 124—5; 1887.
**) Riley, C. V. Bull. 15 pp. Div. Ent. U. S. D. A. 188?

of different gases, and he also concluded that hydrocyanic acid gas was most satisfactory, and in June 1887 published the first account of this material as a fumigant *).

Development in Methods of Generation.

In some of the first experiments, hydrocyanic acid gas was generated in a special apparatus **) outside of the tent and a blower was used to blow the gas under and diffuse it within the tent.

The outside generator was soon superseded by the so-called pot method of generation in which the water, acid, and cyanide were placed in an earthen ware vessel which was placed under each tree. This method of generation was followed without change for a quarter of a century when an outside generator again came into use. This generator, first devised by Dingle and later much improved by Braun, was in use between 1913 and 1916 to 18. As in the original generator it utilized a solution of cyanide, but there was no auxiliary blowing apparatus and the gas which was generated almost instantaneously, was conducted by its own pressure through the outlet hose under the tent. Measured amounts of cyanide solution and acid were conducted into a common chamber and the residue was allowed to accumulate through a set or row of 30 or more trees. In the improved machine a new principle was involved wherein successive small amounts of cyanide solution were added to a large amount of acid and water.***) That is, an amount of acid and water for a set of 30 or more trees was placed in the lower generating chamber, and the cyanide solution added as required for each tree. Such a portable generator was in successful use in California between 1914 and 1918. It represented a great improvement over the pot system in ease of manipulation, accuracy of measurement, and greater freedom from acid burns, and consequent longer life of the most expensive part of the fumigation equipment, namely the tents. But the portable generator method, like the pot method before it, had to give way to the inevitable march of progress.

The next step was a centralized production of gas at special plants and the liquefaction of the gas for convenience of transportation and application to the tree. This method would appear to represent the pinnacle in the development of gas generation. Liquid hydrocyanic acid was first used as an insect fumigant by Mally †) against a mealybug, *Pseudococcus maritimus,* on the grape in South Africa. At practically the same time, and apparently independently, it was used by Dingle for Citrus fumigation in California. In South Africa the liquid HCN is contained in glass ampoules of different sizes which are broken under the tented tree, thus releasing the gas. This method is also used to a limited extent on lemons in Australia.

---

*) Morse, F. W., Bull. 71. Calif. Exp. Sta., 1887.

**) Morse, F. W. Bulletin 73. Calif. Exp. Sta., 1887. Apparatus illustrated in Biennial Report, State Board of Horticulture; State of California, 1887—88. p. 245.

***) Young, H. D., The Generation of Hydrocyanic Acid Gas in Portable Machines; Circular 139, Calif. Exp. Sta.

†) Mally, C. W., Anhydrous liquid hydrocyanic acid for fumigation purposes. South African Journ. of Science, Oct. 1915.

In California the liquid HCN is transported from the plant to the orchard in drums of eighty to one hundred pounds capacity. From these drums the material is transferred to the atomizing machines or applicators by means of which it is measured and atomized under the tree. The same method, in addition to the pot system, is also used for Citrus fumigation in Spain. The liquid method is applicable chiefly where there is a considerable acreage of contiguous planting of Citrus which would warrant the establishment of a plant and thus permit of the transportation of the material to the field by truck.

Potassium cyanide was used in California from the beginning of fumigation in 1886 to about 1909. Sodium cyanide in the meantime had been used for industrial purposes, but it was not considered suitable for plant fumigation, because at that time this salt contained more or less sodium chloride which decomposed some of the hydrocyanic acid. Lounsbury first suggested sodium cyanide for plant fumigation. Newell indicated the effects of sodium chloride on the evolution of the gas, and when free from this impurity it was shown by Woglum that sodium cyanide was suitable for Citrus fumigation, and it was exclusively used in California from about 1909 until it was replaced by liquid HCN about 1917. In both of these salts of cyanide, acid is necessary for rapid evolution of the gas such as is required in Citrus fumigation.

With the more recent production of cyanides of calcium it has been possible to utilize still another method of gas generation. Since calcium cyanides are much less stable than the sodium or potassium cyanides, all that is necessary is to expose the calcium cyanides in more or less finely divided form to atmospheric moisture. One of these cyanides of calcium is manufactured by fusing calcium cyanamid ($CaCN_2$) with sodium chloride ($NaCl$). Another is manufactured by combining hydrocyanic acid with calcium carbide, CaC_2. The use of dry cyanides blown into an enclosure or spread on a surface furnishes a very simple method of fumigation. The ease and safety of transportation and storage make such compounds readily available fumigants for a variety of purposes.

So far as Citrus fumigation is concerned most of the work in Australia is done by the dust method utilizing the first compound mentioned above. Its use on Citrus is limited to regions of low humidity because of the danger of injury, particularly to the lemon tree, which injury appears to be due to the materials in the residue. The second compound mentioned above is much safer to use for plant fumigation, but, aside from a considerable amount used in California in 1926, it has not been used extensively for Citrus fumigation because of the increased cost. The dust method for Citrus fumigation is a very much more simplified method than the pot system, but the liquid method is still more simplified than the dust method because of the simpler apparatus which is used for measuring the dosage and atomizing the liquid under the tent.

Experiments by the writer *) seem to show that less cyanogen is required in these dry calcium cyanides than in liqued HCN to effect the same result on insects and to give the same mean concentration of gas

---

*) Quayle, H. J., Fumigation with Calcium Cyanide Dust; Hilgardia vol. 3, pp. 207—232; Calif. Agr. Exp. Sta. 1928.

in the tent. For example, 1¼ ounces of calcium cyanide containing 30% HCN was equal in results on insects and in gas concentration to 20 cc. of liquid HCN of 97% purity. In these amounts there is about 25% less HCN in the calcium cyanide than in the liquid HCN. From the results on the insects alone there might be a greater potency of the gas, because it is formed from a particle of powder possibly in close contact with the insect or for some other reason. But from the same gas concentration as determined by analyses of aspirated samples from within the tent, it would appear that there is less actual escape of gas through the tent in one case than in the other. Such a differential as indicated did not appear in comparisons with the dry cyanides and the liquid HCN in a gas tight fumatorium.

In the powdered cyanides mentioned atmospheric moisture is necessary for a complete evolution of the gas, and where the relative humidity goes below about 30% there is a considerable retardation in the evolution of the gas in the case of the compound formed from calcium cyanide and sodium chloride, but with the other compound, formed by HCN and calcium carbide, a relative humidity as low as 20% had little effect on the rate of evolution. Where large amounts of such powdered cyanides are used in small enclosures the amounts of HCN in the air and in the powder may be more or less in equilibrium and thus the evolution of the gas may be retarded.

Another form of powdered cyanide, in which HCN is absorbed in diatomaceous earth, is manufactured in Germany and is extensively used, I understand, for ship and warehouse fumigation, and is also being tried for Citrus fumigation in Egypt, South Africa, and Australia. Since in this case the hydrocyanic acid is simply absorbed, or adsorbed, in the carrier material, the release of gas is independent of air moisture.

Manufacture of Liquid HCN.

There are plants for the manufacture of liquid HCN for fumigation purposes in South Africa, Germany, Spain and the United States. There are two plants in the Southern California Citrus area, one using crude calcium cyanide and the other sodium cyanide as the source for hydrocyanic acid. The gas is formed in the usual way and then condensed into a liquid by refrigeration and finally purified to 96—98% by distillation. A small percentage of water is retained to lower the boiling point and thus make the material safer to handle in the field.

Other Gases.

I have been experimenting recently with other gases including carbon tetrachloride, ethyl acetate, ethylene dichloride, ethylene oxide, vinyl chloride, nicotine, carbon disulphide, and chloropicrin, but none of these approach hydrocyanic for Citrus fumigation from the standpoints of insecticidal value and of tree tolerance.

Developments in Tents and Dosage.

While the greatest developments in fumigation have been along the line of gas generation, greater accuracy of dosage through marked tents,

as first suggested by Woodworth and perfected by Morrill, and the working out of dosage schedules in the field by Woglum represent important contributions. The tenting material itself has undergone no important changes. Seven or eight ounce U. S. Army duck or six and one-half ounce drill are the materials at present in use in California. Much of the gas escapes through these fabrics, which represents a great waste of material in addition to the variation in gas leakage on account of the variation in air moisture at different times and places. To secure a fabric that is gas tight and at the same time is flexible, durable and not too heavy is a difficult problem. A pyroxylin treated fabric which I have been testing for the past few years seems to give the greatest promise, but it is too early to say whether such a tent will meet all of the practical field requirements.

Resistance or Tolerance of Scale Insects to HCN.

Up to a few years ago fumigation was uniformly satisfactory for the control of scale insects on Citrus trees, but at the present time the red scale *Chrysomphalus anrantii* Mask. and the black scale *Saissetia oleae* Bern. in certain areas of California have become so resistant or tolerant to HCN gas that these insects in such areas are not now effectively controlled by fumigation. This situation has resulted in a greatly increased use of petroleum oil sprays, but the sprays have not resulted in entirely satisfactory control either, particularly for the red scale. In the case of heavy infestations of either the red or the black scale in the resistant areas both a spraying and a fumigation are necessary.

What we have assumed to be proof of the difference in tolerance of the red scale from different sections of California was obtained by taking infested lemons from the different localities and fumigating them under identical conditions in the same tent.*) Many experiments of this kind showed a uniformly greater survival of insects from the resistant areas. The black scale has been subjected to somewhat similar tests with similar results. Time and place are two important variable factors in fumigation work, but these factors were eliminated in our tests. Moreover, fifteen years of fumigation work in the field has abundantly verified the fact that the red and black scales are more difficult to kill in certain areas than in certain other areas.

How this increased tolerance has come about, and this only in a part of the Citrus area of California, although this area has greatly increased in the past fiften years. I will not venture to answer. If it is a matter of selective population, why has it occurred in restricted areas instead of generally where fumigation has been practiced an equal length of time or even longer? If a different strain of the insect may have originally been established in such areas, why did it take thirty years to show any difference as regards its tolerance to HCN? Mr. Boyce, of the Citrus Experiment Station, is attempting to go into this question rather more tho-

*) Quayle, H. J., Are Scale Insects Becoming Resistant to Hydrocyanic Acid Fumigation; in Calif. Journ. of Agr., 1916. Resistance of Certain Scale Insects in Certain Localities to Hydrocyanic Acid Fumigation; in Journ. Ec. Ent. 15, p. 400—404, 1922.

roughly, and in addition to the two coccids in question as well as certain other insects he is endeavoring to build up a tolerance to HCN gas with the quick breeding *Drosophila.*

Fumigation Practice.

The fumigation of Citrus trees is practiced to a greater or less extent in Spain, Egypt, Palestine, Japan, South Africa, Australia, and the United States. It is much more extensively practiced in Southern California than in all of the rest of the world. In California last year there were about 65,000 acres fumigated or nearly 6,000,000 trees at a total cost of \$2,100,000 or an average cost of about \$35.00 per acre. The most expensive part of the fumigation equipment is represented by the tents for covering the trees, and there are about 20,000 of these tents, representing an investment of about \$1,000,000.

The fumigation of Citrus trees represents a highly standardized method of insect control. The size of the tree is accurately measured, the dosage, in accordance with this measurement, is accurately delivered by machines which are frequently tested as to accuracy, and the gas, which has a high degree of purity, from its nature is or ought to be uniformly diffused throughout the tree. Furthermore, the entire procedure in California, such as the season, dosage, limits of temperature and humidity, and other climatic conditions, length of exposure, condition of the tents and other parts of the equipment, and the qualifications of the men in charge, are all under the official direction of the Country Horticultural Commissioner's office.

Discussion.

W. B. Gurney: Do you aim at sufficient kill by fumigation (or spraying) to obviate need for treatment the following year?

H. J. Quayle: Yes, we do not consider fumigation work entirely satisfactory unless the results are sufficiently effective to last for two years or longer. However, in some sections where there is a combination of scale insects and there are sources of infestation in the neighborhood of the treated grove, fumigation is required every year. Spraying is applied in nearly all cases every year.

Gurney: In Australia dusting with calcium cyanide is the method now generally used for the fumigation. Is the use of liquid HCN more expensive?

Quayle: Liquid HCN may be more expensive in Australia because it is not manufactured in that country. I understand that some of it is being used in Australia, particularly for the fumigation of lemon trees. In this case the liquid HCN is imported from South Africa in glass ampules. Generally speaking, the use of the liquid HCN is restricted to a considerable acreage of Citrus planting which would warrant the establishment of a factory, and close enough by, to enable the liquid to be distributed to the field by trucks, since it can not be transported by rail or water unless contained in special cylinders. Liquid HCN is the cheapest method of fumigation in California.

Gurney: Is oil spraying resorted to in California? It is largely used, as well as fumigation, in Australia and is more effective and cheaper than fumigation.

Quayle: Oil spraying is widely practiced at the present time in California chiefly because two or three of the scales on Citrus have become very resistant to the effects of HCN gas. Until this resistance, which I discussed in my paper, developed in California, spraying as a means of controlling scale insects on Citrus trees made no headway. With the higher priced oils now in use in California there is not very much difference in cost between fumigation and spraying. Where fumigation is effective, it is cheaper than spraying, because an application will suffice for two or three years, whereas spraying must be repeated each year. The unarmored scales are much more easily killed by sprays than are the armored scales. For instance, the red and purple scales in California are not even now effectively controlled by spray alone. Your chief Citrus scale in Australia, I believe, is the red scale.

B. Trouvelot: Do you kill the parasites of the scale insects during the fumigation?

Quayle: The adults of Hymenopterous or Dipterous parasites that may be on the trees at the time of fumigation are killed. The larvae or pupae of these, however, that may be within the host often survive the fumigation, unless they are in the younger stages and are killed by having the host killed. Coccinellid beetles have a little higher resistance to the dosage of cyanide used in Citrus fumigation than the scale insects.

F. Silvestri: Is fumigation done in California by the government or privately?

Quayle: Fumigation is done a) by cooperative fumigation associations, b) by local Citrus associations, c) by private individuals who charge so much for the coverage of the tree, the grower paying for the actual amount of cyanide used, and d) the individual growers where their acreage is large enough to warrant a fumigation outfit.

The most Important Cotton Insects in Turkestan and the Caucasus.

V. V. Nikolsky, Entomologist,

Cotton Committee, Taschkent, Turkestan, U. S. S. R.

It is often thought that the U. S. S. R. (Russia) are so cold that such crops as cotton cannot be raised. We have, however, large cotton plantations in Turkestan and in the Caucasus. Our cotton area this year amounted to about two million acres. It is our good luck that our cotton industry finds itself in an especially favorable situation. We have no such insects as the Cotton Boll Weevil *(Anthonomus grandis* Boh.), *Earias insulana* Boisd., *Albama argillacea* Hbn., *Dysdercus,* and we are also free from the Pink Bollworm *(Pectinophora gossypiella* Saund.)

The more important cotton insects in our country are:

1. *Aphis gossypii* Glover. This pest, as in other countries, usually, injures the young cotton plant. Ordinarily, we have about 20 generations during the year and the quantity of lice rapidly falls off in the autumn. However, in 1927, in connection with the warm weather, additional generations of aphids were produced in the autumn when the cotton bolls began to open. The sweet excretions of the lice dropped on the lint of the opened bolls, and a growth of sooty mold which followed it rendered the lint very dirty. Difficulties soon followed in the cotton gin mills. In the process of separation of the lint the machines became clogged and the productivity of the machines fell considerably. This situation was followed by great confusion in the textile industry. The hands of the workers became dirty, the machines did not work properly, and the production fell. Special conferences had to be called. The Chief Cotton Committee and the Textile Syndicate assigned special funds in 1928 for the study of this phenomenal occurrence. The well known Russian phytopathologist Prof. A. A. Jachevski gave a preliminary determination of the fungi as two species of *Macrosporium,* namely *Macrosporium commune* and *Macrosporium nigricans,* and two species of *Cladosporium.* Naturally, there were also *Trichothecium roseum* and *Penicillium* sp.

2. I will now speak of another cotton pest, that is, the Red Cotton Spider. The latest determination shows that it is of European origin, belonging to the subgenus *Epitetranychus;* the species has not been determined. The Red Cotton Spider created the most terrible devastations, especially in Armenia (in the Caucasus), in some places destroying all of the crop. Such multiplication of this pest stands in close connection with the poor cultivation of the soil in Armenia.

3. A great economical factor in our cotton belt, especially in the Caucasus, is the Cotton Boll Worm *(Heliothis obsoleta* Fabr.). There are years when 20% of the cotton bolls in any cotton area of the Caucasus are infested with this pest. The sowing of maize as a trap crop was the means of control against this pest until recently. Due to the low standard of culture of the local population this measure gave, however, contrary results in some sections of the country, as the people did not destroy the caterpillars. Statistical data showed that in some fields where maize was sown the percentage of infestation of cotton bolls was even higher than where no maize was sown at all. All these facts, in addition to others, forced our entomologists in the Caucasus to look for another plant which could serve best as a trap crop against this pest. Such a plant has just recently been found in the form of the Chick-pea (Mexican "garbanzo").*) The flower of this plant attracts the moths which feed on its nectar. The eggs are also deposited on this plant. The size of the pod is such that the caterpillar, having eaten up its contents, emerges and eats up the pod itself. Often the caterpillar moves from one pod to another. This makes it possible through spraying and dusting of the Chick-peas to obtain a more efficient control against this pest. At the requests of the entomologist, our plant breeders are now interested in obtaining such varieties of the Chick-peas that will bloom at different periods during the growing season.

4. The pests of the greatest importance to our cotton growing regions are locusts. The most destructive of them is *Dociostaurus maroccanus* Thunb., which causes immense damage to our cotton crop. It is known that this locust occupies the pre-mountain regions, and flies from there, in some years, to the cotton growing regions in the "Clay Desert", where it multiplies, and subsequently returns to the pre-mountain regions. In this manner a change in the egg laying location takes place. This flying back and forth of the locust is occasioned quite frequently not through any lack of food, but on account of a specific instinct to change the place for oviposition.

Of great economic importance is also *Calliptamus italicus* L. The wandering of the larvae of this locust is not occasioned through lack of food. The larvae often pass by the finest plants, which they would ordinarily feed on, without touching them. Personally I believe that the cause of this movement of the larvae is a special instinct not to interfere with the moulting of other larvae on these plants. In this way there are simultaneously two groups of larvae, one moulting and the other moving forwards.

Until recently the control of insect pests of cotton was carried on by the Commissariat of Agriculture of the cotton growing republics, while the funds were furnished by the Chief Cotton Committee of Moscow. In 1928 about one million dollars was assigned for this control. The campaign against locusts is conducted from a special fund assigned by the local Commissariat of Agriculture.

The study of cotton pests was undertaken by the Entomological Station at Tashkent, the Entomological Station at Azerbaidjan (Caucasus),

*) Cicer arietinum L.

the section of Plant Protection in Armenia and also by some Agricultural Experiment Stations, as, for instance, the one in Bokhara.

The necessity for protecting our cotton growing areas from foreign pests forced us to devote attention to the pests in our neighboring countries. Our well-known entomologist, Mr. M. M. Siazov, made an entomological survey of Persia. He found no Pink Boll Worm there, but in the central part of that country he found a very important cotton insect, "The Spotted Boll Worm", *Earias insulana* Boisd., which usually destroys about 20% of the crop. There is evidence that this insect was introduced into Persia from India in very recent years. Mr. Siazov noticed a tendency of this pest to move nothward towards our country.

In the northern part of Persia, near the Caspian Sea, the cotton bug, *Nezara viridula* L., was discovered. The biology of this pest was studied by us under the local conditions. This pest caused great damage, and there are indications that it assists in the dissemination of bacteriological and fungus diseases of cotton.

One of the agents of our cotton purchasing organizations discovered the presence of the Pink Boll Worm in Asia Minor near the city of Adana (Turkey). This forced us to undertake strict quarantine measures against Turkish cotton.

Our Chief Cotton Committee devotes much attention to the safeguarding of our cotton regions from foreign pests. In 1925 I was sent to the United States for the study of plant quarantine measures there. In 1925 our government issued a decree with regard to quarantine measures against foreign cotton pests. Upon my return a special commission for cotton quarantines was established. In the near future a special Quarantine Bureau will be formed which will embrace all of the different plant quarantines including the cotton quarantine.

The desire to improve the control of cotton pests and to stimulate the study of those pests forced the Chief Cotton Committee to undertake direct supervision of all the work connected with the combating of cotton pests and the study of their respective life history. The actual control work is being given over to the cotton grower's cooperatives for the purpose of attracting to this work the people who are directly concerned. In 1929 a new Station with 10 branches is to be opened in Turkestan for the study of cotton pests and diseases. These branches will be in a position to move from one place to another in accordance with the needs and interests of the locality. In the Caucasus there will be opened a Station with five branches. All the Scientific organizations which have been conducting a study of cotton pests will get their subsidies from the Chief Cotton Committee in accordance with a special agreement which is now being arranged.

Lubricating Oil Emulsions for Controlling Insects and Mites on Citrus Trees in Florida.

W. W Yothers, and O. C. McBride, U. S. Bureau of Entomology, Department of Agriculture, Orlando, Florida.

(With one text-figure.)

1. Origin of White Fly Investigations.

Prior to 1906, the Citrus Whitefly, *Dialeurodes citri*, and the Cloudy Wing Whitefly, *Dialeurodes citrifolii*, had spread over the greater part of the Citrus section of the State. As the Citrus industry of the State at this time was making a rapid advance, the appearance of the Whiteflies was very discouraging to the growers. Whitefly-infested trees soon became covered with sooty mold, scale insects followed in injurious numbers and the trees were so devitalized that crops were greatly reduced and in thousands of instances a total loss. Owing to the seriousness of the situation, the people of Florida asked for help of the United States Department of Agriculture. In response to this appeal, Dr. A. W. Morrill was sent to investigate these pests and he was in charge from 1906 to 1909. Numerous insecticides were tested and experiments with proprietary miscible oils carried on. Dr. Morrill found that a sulfonated oil produced serious injury to the fruit and foliage. His experiments also showed that another miscible oil was fairly satisfactory in killing Whiteflies. Although fish oil soap had been used for controlling scale insects for many years, he established the fact that is was a safe and reasonably effective insecticide to use against Whitefly. During the summer of 1910. Dr. E. A. Back and S. S. Grossman showed*) that a proprietary lubricating oil emulsion, when applied to Citrus trees, was less affected by the frequent rains than caustic potash fish oil soap. This characteristic made it much more effective as an insecticide than the soap. They found that one per cent or even less of oil in the diluted spray was sufficient for a satisfactory kill of the Whitefly pupae.

The first emulsion of heavy mineral oil or lubricating oil ever used in this state was a proprietary article. Some time in 1906, Mr. John Schnarr of Orlando prevailed upon his boyhood friend, Prof. Henry E. Kalusowski, to devise an insecticide for controlling Whiteflies on Citrus trees. Prof. Kalusowski occupied the chair of chemistry in George Washington University. After experimenting with several formulae,

*) Journ. Econ. Ent. Vol. 10 Nr. 5. Okt. 1927.

the mineral oil, oleic acid, and caustic soda was considered to be the most promising formula. The oil used had an unsulfonated residue of about 64%. As a matter of general interest, it was found in 1907 that their insecticide was very effective in killing the San José Scale on peach trees.

2. Formula.

The senior author thought it advisable to devise some formula that the Citrus grower could make himself. As a basis for this work, the Delaware Station Bulletin 79, August 1907, by C. L. Penny was used; Mr. S. S. Grossman was associated with the senior author during the first year. After several weeks of failure we decided to discard practically all the instructions. We had on hand caustic potash fish oil soap, and this was used as an emulsifier instead of the soap solutions given by Penny. We eliminated rosin, rosin oil, and carbolic acid, and changed the proportions of oil and emulsifier.

The first formula was 2 gallons soap, 1 gallon water and 3 gallons oil to make 200 gallons spray material. It was thought that by using such a large quantity of soap the spray would possess many of the excellent qualities of the soap sprays. After much additional work of a purely empirical nature, it was found that a much greater percentage of oil could be stirred into the soap, if it were done gradually and the stirring vigorous. The only equipment required was a paddle and a bucket; no machinery and no fire.

This was of course only the mere beginning of the work. These formulae had to be tested on a very small scale at first and the toxicity to the insects determined. After this we hazarded their use on an entire tree and finally several groves were sprayed with the mixture. For the first work, we used Diamond Paraffin Oil, having a Saybold viscosity of about 105, and Junior Red Engine Oil with a viscosity of about 220. The results of these experiments are given in the *Florida Grower*, March 31 and April 28, and the *Florida Times Union*, April 20, 1911. More detailed results were published in the *Florida State Horticultural Society, Report* for 1911. After a year or so, the use of heavier oil was gradually abandoned, since the toxicity studies on the pupae of the Whitefly did not show any difference between the Diamond Paraffin and the Junior Red Engine Oil, the latter of course costing much more.

After further work, the soap was reduced to 1 gallon, the oil to 2 gallons, and the water 1 gallon, for 200 gallons spray material. After the beginning of the World War in 1914, the price of caustic potash soap increased and a further reduction of the soap was made. The soap, oil and water were heated to about 168° F and then emulsified by pumping. The new formula was 2 pounds soap, 2 gallons oil, and 1 gallon water. It has been found that heating the mixture is unnecessary.

3. Climate.

The climatic conditions of a given section are very important in understanding the nature of insect pests, their enemies and the relation of insecticides to the host plants as well as their effect in killing insects. The climate of Florida may be said to be subtropical. There is an average

annual rainfall of 54 inches, more than half of which falls in the summer months, June, July, August and September. These months are known as the rainy season. The maximum temperature seldom reaches 100° F, but numerous times reaches between 90 and 95° F. The minimum temperature seldom goes below 22° F, and not often to 30° or 32° F.

The temperature and rainfall records scarcely convey the most characteristic feature of Florida weather, which is the high humidity throughout the entire year, and especially during the summer months. The average relative humidity seldom goes below 50 and during the greater part of each night throughout the year, it is near the dew point. In fact, there are few nights throughout the year that dew is not deposited. With such excessive humidity the evaporation from sprays on the trees is comparatively slow or at any rate it is much less rapid than it is in an arid atmosphere. An insecticide that is satisfactory in Florida might not be suitable for use in a semi-arid or arid climate.

The climate of Florida is responsible for the most characteristic entomological feature, namely the presence of entomogenous fungi. During the rainy season, these fungi thrive and reproduce rapidly. There is scarcely a pest attacking Citrus trees that does not have one or more fungi attacking it. A proper knowledge of the climate and its relation to the development of the fungi is very important in applying artifical means for pest control. The general policy has always been that an insecticide should not be applied during the rainy season or during the months of rapid fungus development, if possible to avoid it. The spraying, in other words, should supplement the work of the fungi. If these have not controlled the insects during the summer, it is advisable to kill the remaining insects by spraying. Then again sprays, to kill insects in Florida, should not have fungicidal properties. In so far as is known, the oil emulsions have little or no fungicidal properties. The entomogenous fungi develop rapidly after their use when there is sufficient population of their hosts for a rapid increase.

4. Ineffective Insecticides.

Since 1906 many insecticides have been experimented with on Citrus trees. Some of these were useless, others showed very little insect toxicity, while still others were exceedingly injurious to the trees and fruit. The miscible oils as a class have proven unsafe and too injurious to the trees to warrant their use. All of these, with the possible exception of one, are highly injurious to trees. A spray composed of soluble carbolineum was ineffective in killing the insects. A spray consisting of 75% carbolic acid was ineffective in killing the insects when used 1 to 50.

5. Injurious Chemicals.

One of the first conclusions arrived at in the experimental work in connection with oil sprays was that most of the injury following the use of certain sprays was caused by chemicals in the material other than the oil itself.*) We found that sprays containing sulphuric acid compounds were highly injurious to both the foliage and fruits. In some instances such sprays caused numerous little holes to appear in the foliage and large

*) Journ. Econ. Ent. Vol. 6. No. 2. 1913.

burned areas appeared on the sides of the fruit. Sprays containing rosin or rosin oil were not so injurious as those containing sulphuric acid compounds, but many instances of severe injury to the fruit followed their use. Sprays containing around 5 to 7% carbolic acid were not so injurious to the trees or fruits as the other sprays. They do not mark the fruit like the preceding sprays, but in several instances they caused the fruit to fall. One of the objections to the use of such sprays is the injurious effects on the operator. After a day or so, especially in the hot sun, the epidermis on the hands and face of the laborers peeled off.

From the beginning of the early work on oil emulsions the idea of obtaining a better or more suitable oil for insecticidal purposes at a cheaper price was kept in mind. The underlying object of the work with oil emulsions for many years was to establish the minimum oil concentration necessary to give a satisfactory toxicity value for all insects. During this period no effort was made to establish the limits of toxicity of the oils to Citrus trees. The concentration of most of the oils tested ranged from ¼ to 2%, the purpose of which was to determine their effect on the different stages of the insects present. Later studies were made to determine the effect of these concentrations on the trees for every month of the year, on trees in full bloom and on all sizes of fruit.

From 1906 to 1924 very little attention was given to the physical and chemical properties of the oils employed. All the oils employed in the experimental work were high in unsaturated hydrocarbons, ranging from 30 to 40%. In the fall of 1924 a few tests were made with oils as low as 4% unsaturated hydrocarbons or oils of about 96% unsulphonated residue. About this time the senior author learned of Gray's work in 1915 and 1916, the results of which were published in 1926 by Gray and de Ong*), who showed that the toxicity of oils to the trees and foliage depends largely upon the percentage of unsulphonated residue in the oils. After learning of Gray's work a series of experiments were started in the spring of 1925 with oils of different physical and chemical properties. In outlining these studies it was necessary to depart from the policy followed for so many years and use them at concentrations that would produce injury to trees. For this study the oils were used at concentrations of 1½, 3, 4, and 4½%. In the 1½% sprayed plots no visible damage developed. The 3, 4, and 4½% concentrations of the different oils were quite variable in the degree of damage obtained. In separating the oils with regard to their toxicity to Citrus trees, three classes were employed:

1. Oils that were found safe to apply at 3, 4, and 4½% concentrations under all spraying conditions;

2. Oils that were safe under certain conditions, but injurious under other conditions:

3. Oils that gave more or less damage under all spraying conditions.

In Table 1 are given the oils studied and classified according to their toxicity to Citrus trees and fruit. It will be noted that oils containing high unsulfonated residue or an unsulfonated residue of 70% or above are safe to apply to Citrus trees at 3 and 4½%. Three oils with unsulfonated residue less than 70% are classed in group 1, or safe oils. These oils

*) California Petroleum Insecticides; in Industrial & Engineering Chemistry Vol. 18, Nr. 2, 1926.

are numbers 1, 3, and 26. Numbers 1 and 3 oils had all received special treatment not known to us, which no doubt accounts for them falling in the safe group. Number 26 is a transformer oil. Oils with an unsulfonated residue less than 70% when applied to Citrus trees at concentrations of 3, 4, and 4½ % usually produce serious defoliation and "burning" of the fruit.

Table I. Oils used during the past four years on Citrus trees, arranged according to tree injury when used at 3 and 4½ %.

1. Safe Oil No.	Viscosity	Unsulfonated residue	2. Uncertain Oil No.	Viscosity	Unsulfonated residue	3. Dangerous Oil No.	Viscosity	Unsulfonated residue
1	157	61.6	27	80	66.0	38	220	69.7
2	105	72.8	28	195	—*	39	238	60.0
3	281	69.2	29	230	64.8	40	177	64.0
4	138	96.0	30	70	70.8	41	80	66.0
5	190	92.0	31	81	66.0	42*	—	—
6	312	96.4	32	100	66.4	43	150	64.8
7	150	70.0	33	153	68.0	44	171	62.2
8	134	97.2	34	177	64.0	45	431	72.0
9	111	94.8	35	176	67.6	46*	—	—
10	51	88.4	36	158	62.0	47*	—	—
11	56	77.6	37	166	60.4	48	325	60.0
12	60	89.6	—	—	—	49	152	68.0
13	94	85.6	—	—	—	50	230	64.8
14	124	72.8	—	—	—	51	147	65.2
15	145	80.4	—	—	—	52	—*	64.3
16	151	74.0	—	—	—	—	—	—
17	76	97.2	—	—	—	—	—	—
18	81	93.2	—		—	—	—	—
19	96	94.8	—	—	—	—	—	—
20	92	96.8	—	—	—	—	—	—
21	102	95.2	—	—	—	—	—	—
22	97	93.2	—	—	—	—	—	—
23	101	86.0	—	—	—	—	—	—
24	140	96.0	—	—	—	—	—	—
25	300	97.2	—	—	—	—	—	—
26	82	68.0	—	—	—	—	—	—

*) No determinations.

The value of the physical and chemical properties of oils as a means of selecting good spray oils have been studied on 47 different oils, Table 1. The relation of unsulfonated residue to injury is apparent as shown when the per cent of unsulfonated residue is correlated with injury, r = 0.6910, or a high correlation between injury and the amount of unsaturated hydrocarbons in the oils. In figure 1 is shown the relation of injury to unsulfonated residue (p. 170).

The correlation between injury and viscosity was 0.4172. This is just about the level of significance. The viscosity, however, cannot be employed as an absolute guide for selecting oils safe to Citrus trees. These data show that the oils of higher viscosity are more likely to be injurious than the oils of low viscosity. A few oils of a low viscosity gave serious damage, while other oils of a high viscosity were found safe. Viscosity, therefore, cannot be employed as a basis for selecting spray oils.

The specific gravity has often been suggested by entomologists as a basis for selecting spray oils. Specific gravity indicates to some extent the nature of an oil and may be used as the first clue in selecting an oil. The relationship between injury and specific gravity is shown by the correlation coefficient of 0.4925. Heavy oils are more likely to produce

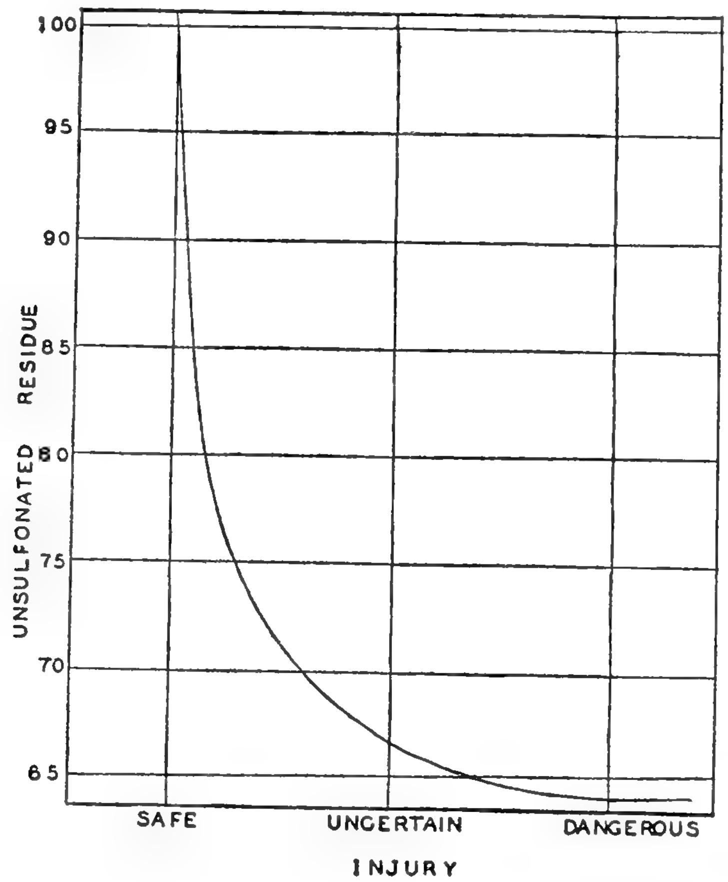


Fig. 1. Showing the relation of injury to unsulfonated residue.

injury than the lighter oils. This test, however, does not disclose the actual constitution of the oils, nor does it furnish a satisfactory guide for selecting spray oils. A light and heavy oil may be mixed in different proportions to obtain a product of any specific gravity between those of the original oils.

Of the physical and chemical tests now reported, the sulfonation test furnishes the most satisfactory means of selecting a good oil for spray purposes. It should not be lost sight of, however, that this is not the only test. Other treatments of the oils may be found also to produce high grade spray oils.

6. Concentrations Necessary.

Exhaustive counts have been made to determine the required concentration of oil necessary to kill the pupa of Whitefly, *D. citri.* These certainly show that 1% is the maximum required, and more than likely less concentration would be satisfactory. The Florida Red Scale, *Chrysomphalus aonidum,* is, we believe, the most resistant scale to sprays on Citrus trees in this State. Careful counts show that 2% of oil carefully applied will kill every adult female scale hit by the spray. The dilution required for various other insects ranges from the minimum of 1% to the maximum of 2%. It is only in the rarest instances that any Citrus grower uses more than about 1.35% to 1.45% of oil in the material. Perhaps more than half of the spraying is done with material containing about 1% of oil.

7. Species Controlled.

Citrus trees in Florida are infested with about the same species of insects and mites throughout the year. The various species vary in abundance during different times of the year, and different species are also present in different stages. But as a whole the population is quite uniform. Under such conditions, the value of an insecticide depends largely upon the number of species and stages of different species killed by the treatment. The oil sprays are effective against practically all species of insects and mites present. The several species of Whitefly are easily controlled as well as the several species of Scale Insects, such as the Red Scale, Purple Scale and Chaff Scale. The Purple Mite, *Paratetranychus citri*, is very easily controlled by the oil sprays, 1% being entirely satisfactory for this purpose. These are much better than lime sulphur solution. There are no data to show the effects of the oil sprays on *Paratetranychus sexmaculatus*, or the Six-spotted Mite. Owing to the characteristic habits of this species, occurring on the under surface of the leaf surrounded by more or less web, the popular notion exists that the spray is not effective against this species. The oil sprays are only effective in killing rust mites when these are actually hit by the spray. Sulphur sprays and dusts, as is generally known, kill rust mites without actually coming in contact with the mite. Oil sprays of course do not have this quality. After many years of trial it is not considered good orchard practice to depend very much upon the oil sprays for controlling rust mites.

8. Limitations in the Use of Oil Sprays.

When the oil sprays were first introduced into Florida, it was not considered good policy to set forth, to any extent, their faults or objections to the use of them, since one of the main objects was to get people to use them for Whitefly and Scale insect control. At the present time, however, the situation is entirely different and it is advisable to set forth some of the objections to the use of oil sprays on Citrus trees.

9. Frost.

It has been known since Hubbard's work in 1885 that severe injury would follow the use of kerosene emulsion applied to Citrus trees when followed by low temperature. It has been observed by us numerous times that, if frost followed the application of the lubricating oil emulsion within two to three weeks, nearly complete defolation would result. In some instances, branches are killed. One case last winter was very striking. The entire grove had been sprayed in late September. During the spraying of the last half of the grove, the machine did not work properly and it was decided to spray this half the second time in early December. On January 1st the temperature went to 21° F. This half of the grove was practically defoliated, while the half sprayed early in the season was scarcely touched by the cold.

10. Coloring.

Citrus fruits in Florida are recognized as legally mature when the ratio of total soluble solids to anhydrous citric acid is 8 to 1 or above.

Even at the time the early varieties pass the 8 to 1 ratio, they are more or less green in color. Before shipment the natural color of the fruit is brought out by the use of Ethylene gas. There has been considerable complaint on the part of packing house people that fruit sprayed with oils a short time before picking color very slowly or not uniformly.

11. Maturity and Injury.

Oil emulsions not only retard the natural coloring of the fruit peel, but influence the normal changes in fruit composition.

It was noted in the very beginning that oil sprays applied to young or immature Citrus leaves prevented the turning of the leaves from a light green to a dark green or prevented the formation of chlorophyl from 10 days to 2 weeks. This injury has always been considered most temporary in character, but nevertheless it is one of the minor objections to the use of these sprays. In so far as causing any injury to full grown leaves, there is no visible indication that oil sprays are injurious. They may have, and probably do have some effect on the function of the leaf, but such effect is not visible to the eye. Oil sprays must not be used at unnecessarily great concentrations or at too frequent intervals. If used at too great concentration, such as 4½% of oil in the diluted material, a large proportion of the bearing wood will be killed outright and one or more crops will be lost before the trees recover. The injury at 3% would be almost negligible in most instances, but in some cases small branches would be killed and considerable defoliation would occur. Injury follows the application of 2% only in rare instances, and at 1½% practically none at all. If used at too frequent intervals, such as three or four applications of 1 to 1½% at intervals of six weeks, the fruit becomes stunted and the leaves do not reach their normal size. In the fall, when the fruit should be ripe, it is green in color and the acid and sugar content is very low. The following year such trees do not bloom as vigorously and do not bear as much fruits as normal ones. When oil sprays are applied to Citrus fruit ranging in size from ½ inch to 2 inches or more in diameter, there appear shadows. These shadows are caused by the oil entering the stomata, giving the area a darker shade of green than adjoining areas. These shadows as a usual thing disappear in a period of about two weeks, but, if very intense, their disappearance may not take place for a month or six weeks. As a usual thing these shadows are not considered to be of any importance, but in some cases they do become permanent. So far as is known, they are caused by every kind of oil known. They follow kerosene emulsions as well as all kinds of red oils and white oils. The more highly refined the oil, the more intense and the more persistent the shadows. The greater the viscosity of the oil, the longer the shadows persist. It has been known for many years that trees suffering from the lack of moisture and during a prolonged drought are much more liable to be injured by oil sprays than trees amply suplied with water. The oil seems to enter the foliage and fruit to a much greater extent then if they were turgid or full of water. Very few growers will spray trees under such conditions.

12. Spray Combinations.

The use in combination of different insecticides adapted to kill different kinds of pests which may be present on the trees at the same time is an alluring but treacherous field. Since the cost of applying an insecticide is usually about equal to the cost of the material, great saving results when different materials are applied at the same time. This feature is very appealing to both investigators and Citrus growers.

The dangers arise in that different sprays may not be compatible, and, even if compatible, may not possess the same insecticidal properties when used in combination, and may not affect the trees the same as if applied separately. From about 1895 until 1909, the self-boiled caustic soda sulphur solution was the main insecticide used for the control of rust mites. After the introduction of the lubricating oil emulsion made with soap, it was found by E. W. Burger that they could be combined without any great chemical change. It was found that, when combined, they were apparently compatible. Experiments showed that little or no damage should be expected from this combination. For several years this combination was used to control Whiteflies, Scale Insects and Rust Mites with one application. After a while an insecticide firm put soda sulphur up in a powder form under the name of soluble sulphur. This entirely displaced the solution made by the growers. This was sold in great quantities in the State for several years. Gradually, however, it was abandoned entirely by the Citrus growers, and at the present time there is not a single grower in Florida who uses the combination. This situation was brought about by a few growers getting considerable injury from the combination, and perhaps by the entire displacement of liquid sprays with sulphur dust for Rust Mite control. The U. S. Department of Agriculture recommended the combination until recently. Under the proper conditions it is all that has been claimed for it, but when applied during excessive heat, serious injury may follow its use. The last time it was used in our experimental work, serious injury resulted in spotting the fruit.

The use of soda sulphur alone for Rust Mite control was displaced by lime sulphur solution, which was much more effective and which could be used at a much greater concentration than the soda sulphur. The next step which appealed to the growers as well as the investigators was a combination of lime sulphur solution with the oil sprays. This was accomplished by adding a stabilizer, such as glue, casein, milk powders and starch, to the soap emulsion. Several firms recommended this combination, and after experimenting with it for considerable length of time, the Government recommended it.

About this time Kaolin was used as the emulsifier for the oil. The Kaolin emulsion would mix with lime sulphur solution without any added stabilizer. The Kaolin emulsion and the lime sulphur combination was used three summers by us without injury. The fourth summer about 3 to 4% of all the grapefruit sprayed with it was ruined and since that time we have discouraged its use. Probably few if any Citrus growers at the present time use lime sulphur solution in combination with any oil emulsion, or if it is done at all, it is very rare indeed.

As a general condition there is little or no occasion for the use of nicotine sulphate or extracts of derris on Citrus trees. An exception to this condition came about with the epidemic of the Citrus Aphid a few years past. Experiments showed that the oil emulsions, unless used at 2%, were not satisfactory and that in the spring of the year the concentration of 2% was greater than should be applied. When either nicotine sulphate, 1 to 800 combined with 2/3 of 1% of oil, or 5% extract of derris, 1 to 800 and 1% of oil, the results showed that the spray was entirely satisfactory for Whiteflies, Aphids and Scale Insects. Of course, Red Spiders and Rust Mites were fairly well controlled also. The toxicity of these combinations seemed to be just as good as if each spray had been applied separately. In fact, the results showed that they were more effective on Aphids than if used alone. No injury resulted from the combinations when used in the spring of the year, except to a variety of oranges known as Temple which is undoubtedly closely related to the Mandarin family. White oil caused no damage to these trees, but the so-called lubricating oils did cause serious defoliation to this variety.

13. Bordeaux Oil Emulsion.

Citrus fruits in Florida are infected with several fungus diseases. Bordeaux has long been recommended as the most effective fungicide for the prevention of these diseases. The opportune time to spray for one of them, Melanose, coincides approximately with the time when Scale Insects and Whiteflies are satisfactorily controlled. The oil emulsion added to the Bordeaux makes an effective combination spray for the prevention of diseases and the control of insects. When used in the winter time for the prevention of Citrus scab, it will also act as an effective insecticide and fungicide. As explained heretofore, the use of fungicides in Florida curtails the normal development of the entomogenous fungi. After the use of a fungicide, the insects and mites increase at an almost unbelievable rate. The use of oil in the Bordeaux kills a large part of the pests present at the time. Rapid increase, however, necessitates following up Bordeaux with both oil emulsions for the control of Scale Insects and Whiteflies, and sulphur dust and sprays for killing Rust Mites. If no remedial measures are taken after the use of Bordeaux or even Bordeaux oil for the control of insects and mites, the fruit will be much more seriously blemished, and trees much more seriously damaged by insects than ever could be done by any of the fungus diseases. In other words, the prevention of the diseases would result in a worse condition than if nothing had been done.

The Development of a Control Program for the Mexican Cotton Boll Weevil and some of its Results.

W. E. Hinds, Entomologist, Louisiana Experiment Station, Baton Rouge, La.

Introduction.

A full history of the development of the control program for the Mexican Cotton Boll Weevil (*Anthonomus grandis* Boh.) would tell nearly the full story of the progress of agriculture throughout the Cotton Belt during the past quarter of a century. Only a few of the most outstanding features in this story can be discussed in this brief paper.

Throughout eleven of the Southern States stretching from North Carolina to Texas and including Tennessee, Arkansas and Oklahoma, cotton has long been the principal staple crop produced. In most of these States, with the exception of Florida, the value of the cotton crop exceeds the combined values of most of the other field crops produced as a source of cash income to the farmer. With the invasion of the boll weevil, the status of the cotton crop was changed immediately from that of the most certain crop that could be raised to a very uncertain crop in the presence of the weevil. The whole economic system of the Cotton States was based upon the cotton crop, and the great majority of cotton planters were dependent upon "advances" made to them by bankers, merchants or land owners for the production of the crop. The boll weevil, therefore, affected directly practically the entire agricultural and economic systems of the Cotton States, and the development of the control program has therefore been equally broad in its effects.

HISTORICAL REVIEW.

The Mexican Cotton Boll Weevil was described by Boheman in 1843 from specimens collected in the vicinity of Vera Cruz, Mexico. Nothing was known about the food habits of the species until about 1885, when Dr. C. V. Riley reported the breeding of specimens from dwarfed cotton bolls sent in from the State of Coahuila in the Northern part of Mexico. Later it was learned that this weevil occurs generally upon the wild native cottons growing on the tablelands in Central America and Mexico. Cultivated cotton suffered more from it than did wild cotton, and the weevil advanced northward as the culture of cotton increased in Northern Mexico until it reached the Rio Grande Valley in 1892 and spread across the national boundary into Southern Texas.

The spread of the species has occurred principally by flight and has continued steadily, in a northerly and easterly direction especially, until

the weevil has reached practically the limits of commercial cotton production from Oklahoma eastward to North Carolina. More than 90% of the cotton-growing area is infested, with every prospect that the infestation will continue as long as the production of cotton continues. Throughout this infested area, the capacity of the weevil for damage is affected year by year by extremes of climatic conditions in summer or in winter. While the factors of natural control are of great importance in their effect on weevil damage, we shall have to omit consideration of them in order to consider more fully the control measures which have been developed and are under the control of the planter to a fuller degree.

Weevil Damage.

As is true with many newly introduced pests, the boll weevil has inflicted its heaviest losses during the first five or ten years after its invasion of any section. Thereafter the planter prevents or offsets part at least of this destruction by making certain changes in his methods of producing cotton. In the early years of weevil infestation, in Texas, Louisiana and Mississippi, especially during seasons, or in areas where more than normal rainfall occurred, the destruction of cotton was frequently more than 65% of the normal yielding capacity and sometimes reached 100% of the crop. Occasionally on areas of a thousand acres or more so little cotton escaped the weevils that it was not worth the effort to pick it over at all.

A concrete illustration of the serious effects of this boll weevil invasion was shown in the State of Louisiana where, before the weevil invasion, the average yield of cotton per acre was usually larger than in any other State. The average annual crop in Louisiana during the six years period from 1899 to 1904, before weevil invasion, was approximately 840,000 bales. The crop then fell rapidly as the weevils spread across the State from 1904 to 1909. Many planters and advancing merchants were ruined and banks failed as a result. The State crop was reduced to 253,000 bales in 1909 and 235,000 bales in 1910. This crop represented approximately 30% of the normal cotton production. Even during the next five years the average became only about 380,000 bales. This was before the development of insecticidal control measures became established as an aid in protecting the increased yielding capacity which resulted from improved cultural methods.

The degree of recovery experienced in recent years is indicated by the average crop of 762,634 bales which has been produced in Louisiana from 1925 to 1927. Cotton production throughout the United States has shown a somewhat similar degree of improvement in recent years, until the cotton consumers of the world may now feel assured that the United States will continue to supply the major part of the world's supply of cotton for many years to come and at a reasonable price.

Development of the Control Program.

The first deliberate and sustained effort to decrease the ravages of the boll weevil was begun in Texas in 1902, when the U. S. Bureau of Entomology established its Boll Weevil Laboratory there under the di-

rection of the late W. D. Hunter and with the writer in charge of the Laboratory work. This Laboratory has been continued to the present time and has been one of the most important factors in developing, in cooperation with State Officials, the present effective program for fighting the boll weevil.

In the early years of this investigation it became apparent that certain changes might be made in the usual cotton cultural practices with a good prospect of reducing the damage done by the weevil to the crop. The only way in which planters could be induced to make these changes was to enter into a legal contract, whereby the Department of Agriculture agreed to reimburse them for losses incurred, if they would follow faithfully the practices recommended by the Entomologists and should fail to secure at least as good a yield as they had secured on the average by following their own methods on the same ground during the three preceding years. These contracts were multiplied until more than 50,000 acres of cotton were being grown in this way by 1904. The soundness of the recommendations, which were all cultural, is shown by the fact that in no single case was reimbursement ever called for.

The demand for a greater extension of these beneficial cultural practices throughout the weevil-infested area, and even in advance of weevil infestation, became so great that in the spring of 1904 Dr. Seaman A. Knapp was placed in charge of the organization of "The Farm Demonstration Work". "Farm Demonstration Agents". were appointed by Counties to show the farmers who were willing to cooperate just how cotton should be raised to offset weevil damage. The beneficial effects of this new type of agricultural service work were so impressive that the demand for it spread far outside of the Cotton Belt, and ten years later it was made National in scope under the Smith-Lever Bill and known since as the Extension Service.

It is certainly interesting to consider how the fight against the boll weevil has led step by step to this National Organization with its far-reaching benefits to the rural homes and to all ages of people and to all types of agriculture and animal industry throughout the Nation. There is no "disguise" to this blessing.

Cultural Methods in the Weevil Fight.

All of the cultural methods which have come to be recommended for cotton production under weevil conditions are simply sound agricultural practices which should be generally followed and which would be equally advisable regardless of the presence or absence of the weevil. They are designed to increase the "yield per acre", and experience has abundantly proven that, as "yield per acre" increases, the "cost of production" per pound of lint cotton usually decreases decidedly. Therefore, the prospect of profit from the production of the crop is much greater when the yield secured is considerably better than the average.

In addition to the cultural measures designed to increase yielding capacity, there have developed several recommendations for practices which help to repress weevil infestation or decrease the proportion of weevils hibernating successfully. Finally we must consider the development of

"insecticidal control", which constitutes really the cotton farmer's best "insurance" against the boll weevil.

The principal practices included in the cultural program for cotton may be summarized very briefly as follows:

Select fertile, well drained fields of high yielding capacity.
Prepare the soil thoroughly. Fall ploughing is advisable.
Throw up the beds fairly early in spring and at 3½ to 4 ft. apart.
Fertilize liberally with appropriate and balanced food elements.
Plant moderately early, usually April 15 to May 15.
Use best improved seed obtainable, of varieties suited to locality.
Chop out promptly, leaving a stand of from 15,000 to 20,000 stalks per acre. Close spacing nearly always increases yields.
Apply a liberal side-dressing of Nitrates after chopping.
Cultivate frequently and always shallow to keep down grass and weeds and promote long continuing growth in the plant.
Pick out the crop promptly.
Bury all green cotton stalks as early in the fall as possible.
Rotate cotton fields with legume crops for soil improvement.
Winter growing cover crops should be used where possible.

Insecticidal Control Measures.

The present program for insecticidal control of the boll weevil has developed out of the practically continuous experimentation which has been under way during the past twenty-six years.

The first insecticidal control efforts involved the use of cheap molasses in the hope that the weevil might be attracted to and killed by a sweetened poison. These tests showed positively that the boll weevil is not attracted to "blackstrap molasses", although it is attracted somewhat to higher grades of sweets and especially to high grade honey.

Rather extensive tests made with Paris Green showed clearly that, while many weevils were killed by this poison, the injury by the water-soluble arsenic contained therein caused greater damage to the growth and fruiting of the cotton where it was used than the boll weevil was likely to do without any effort at its control. The use of this material in either dust or spray applications seemed inadvisable.

Continuing in the effort to find an effective and practicable method of poisoning the boll weevil, Mr. Wilmon Newell, Secretary of the Louisiana Crop Pest Commission, and his Assistant, Mr. G. D. Smith, conducted extensive tests with powdered arsenate of lead during the seasons of 1908 and 1909. These dust applications, although made with very unsatisfactory types of dusting machines, still showed a considerable increase in yields and a fair margin of net profit as a result of the dust applications. The highest profits were secured usually where five applications were made. In Louisiana Circular No. 33, page 328, Mr. Newell states: "In the light of our present knowledge the best results will follow from about five applications, made from 5 to 7 days apart, the first one being made at the time of appearance of the first square in the cotton field." He also emphasizes the necessity for using suitable dusting machinery which will drive the poison through the plants, and that it cannot be applied satisfactorily from a bag.

The next and greatest advance in poison control methods has been the work conducted under the direction of Mr. B. R. Coad at the Delta Boll Weevil Laboratory, Tallulah, Louisiana, since about 1912. This work has been based upon the comparatively new insecticidal material, calcium arsenate, which has been modified and finally "standardized" to a higher degree than any other of our arsenical materials. Along with the improvement in the poison has gone also very great improvement in the construction of dusting machinery for its application. Possibly this mechanical side of the work may be considered the most important contribution toward practicable weevil control. It has involved the development of a number of types of dusting machines adapted in their capacity and cost to the various areas and conditions for with they are needed. These types, while designed primarily for the treatment of cotton, are finding a wide field of usefulness throughout the world in the treatment of all other kinds of crops and for innumerable kinds of insects.

The simplest form of dust gun called the "hand gun" is a single row machine with the dust hopper usually in front of the operator and the dust discharge carried by a blast of air from a highly geared fan driven by the arm of the operator so as to give a continuous discharge. The "saddle gun", is practically a double hand gun with two fans and operated also by cranks and dusting two rows at a time. The "traction machines" are of two and three row types and in these the fans are driven by connection with the wheels or axle of the machine. The power, therefore, comes directly from the mules or horses drawing the machine. The capacity of these machines extends upward to the coverage of from thirty to thirty-five acres in a night. The use of powerful lights on these larger machines facilitates the working under night conditions when the air is still, the plants are moist and the most successful dusting is accomplished.

The highest development of the cotton dusting operation has been the perfection of the "insecticide dusting airplane". With the best of these machines an acre of cotton can be dusted thoroughly in less than two seconds and with a thoroughness and efficiency that is superior to the work of any other type of machine. Hundreds of thousands of acres of cotton are now being protected against the attack of various insect pests by the use of airplanes.

In the insecticidal control program the application of poison should often begin on young cotton before squares form. This one application made at this stage of the plant for the destruction of over-wintered weevils before they can deposit any eggs is known as the "pre-square poisoning". The regular series of poison applications to fruiting cotton begins when about 10% of the squares show weevil punctures. The developmental period of the weevil is about eighteen days on the average and, therefore, it has been found necessary to keep the poison on the cotton continuously through at least this period of time to secure a high degree of weevil control. This requires three or more applications at intervals of four or five days, or rather nights, apart as a minimum dusting program and further applications as may be needed to keep the infestation of squares below 20%, until the cotton plants have had time to set practically a full normal crop of bolls and these bolls have become more than two-thirds grown, after which they are practically safe from weevil damage.

Profitable Results from Weevil Control.

The cotton dusting program has been practiced increasingly throughout the South during the past ten years. The general experience has proven that by its proper use under conditions of average to heavy weevil infestation the planter saves from weevil destruction practically one-third of the normal yielding capacity of his crop. The saving is often measured by from 300 to 500 pounds of seed cotton per acre increase in yield on poisoned fields above the yield of similar fields, or portions of the same field, which are not poisoned. Proper poisoning is now considered as essential a step in the most profitable cotton production, as is the use of improved seed or commercial fertilizers.

The effect of all of this upon the "cost of production of cotton" is very striking. Under recent prices and costs, it is found that, where the "average yield" of one-third bale per acre of cotton is produced, it costs more than 20 cents per pound to produce it. In contrast with this, the reports submitted by the State Prize Winners in Cotton Production throughout the South during the past three years have shown that with their yields averaging practically 2 bales per acre (instead of one-third bale per acre), their total costs per pound ranged from 5 cents to 9 cents. In all of these high yields, the full program of weevil control, in addition to the best of cultural measures, has been applied.

The benefits resulting from the fight against the boll weevil are too numerous to be fully enumerated, but among them we must consider that it is now easily possible to produce cotton at a greater profit than before the weevil occurred. All farming operations are being studied more intelligently and improved more rapidly. The standard of living and of health on the farms has been greatly improved. Both the agricultural and economic systems of the Cotton Belt are now upon a far sounder and more permanent basis than formerly. The development of the Extension Service has added a new method of universal applicability for the improvement of all conditions of life among rural people and for making rural citizens of higher character and greater usefulness.

Hessian Fly Control in the United States.

C. M. Packard, Senior Entomologist,

Bureau of Entomology, U. S. Dept. of Agriculture, West Lafayette, Indiana.

Historical.

The methods now used for the control of Hessian Fly *(Phytophaga destructor* Say) in the United States have been known and practised for nearly 150 years. Injury to wheat by this insect first began to claim attention about the year 1778. Before 1800 the farmers and naturalists of that time, in casting about for ways and means of meeting this new enemy, had discovered almost all of the practical methods of reducing Hessian Fly injury known to the present-day entomologist (1, 2). Burning and plowing-under infested stubble, stimulating the growth of wheat by fertilization and cultural practices, late sowing and the use of resistant varieties are all mentioned in discussions of the Hessian Fly published before 1800. More intensive studies by modern entomologists, however, have resulted in more effective application and more accurate knowledge of the value or futility of the control methods practised or suggested many years ago by our forefathers.

Life History and Openings for Attack.

Since a knowledge of the life-history of the Hessian Fly is necessary to the intelligent consideration of control measures, it may be sketched briefly for the main wheat region of the United States as follows. There are at least two main generations a year, one in early spring and one in early fall. In most years there are also two additional generations, usually minor ones, one in early summer, and one in mid or late fall. This insect passes the winter in the young wheat in the form of a larva in a puparium. In early spring pupation takes place and soon after active plant growth begins, adult flies commence to emerge from the puparia and oviposit on the growing wheat. Individual adults live only two or three days, but spring emergence and oviposition may extend over several weeks. The eggs are laid on the upper surfaces of the leaf-blades and hatch in about a week. The resulting larvae crawl down the blades and under the leaf-sheaths to a point just above the junction of the leaf-sheath with the stem, close to the plant crown. Here they become stationary and feed by extracting the sap from the stem. This is the stage in which the injury to the plant occurs. In about two weeks they become full grown and form puparia. A portion of this new generation may pupate immediately and serve as the source of a second spring brood in the same wheat. By the time this second brood of flies issues the wheat has begun to increase

rapidly in height. Hence these adults oviposit largely on leaves originating from nodes of the stem above the plant crown, and their progeny, together with those of late-appearing first-brood flies, form the puparia to be found at harvest time just above the nodes of the stems rather than at the plant crown. Weakened and broken-over stems usually result from the feeding of the larvae at the nodes.

By harvest time practically all the larvae have formed puparia. The summer season is passed mostly in this stage. Though copious moisture at any time may stimulate a few or all of them to pupation and emergence, this usually does not occur to any extent before late summer or early fall. With the advent of suitable weather conditions for germination and vigorous growth of volunteer wheat pupation begins. The time, magnitude and duration of adult emergence in the fall depends on the temperature, rainfall and abundance of puparia in the stubble. It usually occurs in September. Volunteer and planted wheat present at this time become infested. Wheat appearing above ground after the main emergence of flies usually escapes serious infestation in the fall. Favorable weather conditions, however, in some autumns or in more southerly latitudes, may enable the fly to develop a second fall brood which may infest the later-sown wheat. Usually by the time cold weather arrives all individuals have reached the puparium stage in which they pass the winter under the leaf-sheaths of the young wheat.

The extreme variation of climate in different parts of the United States causes a like variation in the seasonal history of both wheat and fly. As a result control methods must be adapted to local conditions. Some of the most effective measures in the main wheat area comprising the central and eastern United States are not applicable in the wheat regions of the extreme north and west. Fortunately the fly is not as serious a pest in the latter regions, the climatic and cropping conditions being less favorable to its multiplication.

Natural factors influencing Fly abundance.

1. Meteorological.

Hessian Fly activities are intimately dependent on and greatly affected by the weather. Continuous observations in the field show that climatalogical conditions are the most important factors influencing fly abundance. The rapid increase of infestation in 1927 in Pennsylvania, Maryland and Virginia was the direct result of abundant late-summer and early-fall rains in 1926. These rains caused the general growth of volunteer wheat and active pupation and oviposition of the flies. Their rapid multiplication in 1926 was further augmented in 1927 by weather conditions favorable to their development. Meteorological conditions were plainly responsible for the sudden rise from innocuous infestations in the spring of 1926 to one causing severe injury in the fall of 1927. A similar development occurred in south-central Kansas and north-central Oklahoma the same years. In Illinois, Indiana and Ohio, on the other hand, the increasing infestation of 1926, due chiefly to the abundance of volunteer wheat, was arrested by weather conditions during 1927 comparatively unfavorable to fly development. In these states fly emergence and oviposition were retarded in

the spring by chilly, rainy weather, and again in the fall by shortage of moisture until so late in the season that low temperatures became the retarding factor. The Kansas and Oklahoma infestations were suddenly cut down in the spring of 1928 by a cold storm with freezing temperatures just at the time of main spring pupation and emergence. It seems clear that major climatological variations, affecting the entire fly population in a locality rather than only a portion of them as in the case of parasitism, are the predominant forces influencing Hessian Fly abundance.

It has long been known that copious moisture in combination with clear, warm days is necessary to stimulate fly activity and general germination of volunteer or planted wheat for the flies to infest. But the importance of weather conditions unfavorable to fly activity does not seem to be so generally realized. The increase of parasitism has often been assumed to be the reason for reduced infestations when in reality the controlling factors were meteorological. Among the climatic phenomena observed to have had a profound reducing effect on fly abundance are: severe storms and freezing temperatures occurring when the insect was largely in the susceptible pupal, adult, egg and early larval stages; extreme heat and low humidity occurring before the flies have fully attained their resistant quiescent puparial form; and protracted drouth or low temperatures inhibiting their activity at periods of the year when development of the insect and its host plants normally takes place. Since there are so many unfavorable meteorological conditions, one or more of which are likely to occur every year at critical times in the life of the fly, the chances are much greater that their activities will be limited than that they will be favored. As a result extremely heavy infestations are the exception rather than the rule and are brought on only by an unusual succession of two or three favorable seasons.

2. Parasites.

There are 29 species of parasites of the Hessian Fly known in the United States, all Hymenoptera, but few of these species have ever been known to occur in sufficient numbers to affect materially the abundance of the host. Contrary, perhaps, to general belief, rather extensive studies in recent years indicate that parasitism is seldom the dominant factor in reducing or preventing Hessian Fly outbreaks. Instances have been observed where parasitism in a locality approached 100%, but even 90% parasitism is unusual. The ability of the fly to multiply rapidly is so great that even though 90% or more of a brood may be parasitized, the surviving 5 or 10%, given favorable conditions, may be sufficient to produce a material infestation in the next crop of wheat. At the same time, as shown by Hill and Smith (4), 30 to 75% of the flies are eliminated each year by the parasites, and there is no doubt that if it were not for them, injurious infestations would be more frequent and more intense. No feasible way of artificially increasing parasitism has yet been devised. We must therefore depend on more direct methods of preventing crop reduction by this insect.

Artificial Control.

There are several points in the life-history of the Hessian Fly at which the insect is open to attack. The exposed position of the eggs and

migrating larvae on the leaf-blades suggests the use of insecticides. The feeding larvae concealed under the leaf-sheats suggest the possibility of artificially changing the plant constituents in some way detrimental to larval development. The occurrence of qualities in some wheat varieties rendering them unsuitable to the feeding larvae suggests the feasibility of breeding more desirable and more highly fly-resistant varieties. The presence of the fly exclusively in the form of puparia in the stubble during the summer offers a practical chance to eliminate them by destruction of the stubble. The immediate need of the adults emerging from the stubble for young growing wheat on which to oviposit affords a practical opportunity to prevent their propagation by depriving them of the necessary young wheat, either volunteer or planted.

The last two of these possibilities, that is, eliminating infested stubble before fly emergence, and preventing the presence of any young wheat at the time the flies emerge from the stubble, are the only practical methods yet developed for effectively reducing fly infestations. Their application has been quite thoroughly worked out, and while they are usually effective it must be admitted that they have their limitations. Before discussing them further, therefore, consideration of the other avenues of attack is desirable, since it is evident that we must either consider the Hessian Fly problem satisfactorily solved, or else we must look in other directions for more effective control methods.

Possibilities for better Control Methods.

1. Insecticides.

Both sprays and dusts have been tried experimentally, but at least five difficulties interfere with their practical use: the expense of application as compared with the margin of profit on the crop; the necessity for more than one treatment, due to the length of the oviposition period and the rapid development of new leaves by the plants; the need of a suitable insecticide; the necessity for expensive special machinery not ordinarily possessed by wheat growers or useful to them for other purposes; and the fact that the application of insecticides is an extra operation which cannot be combined with any routine cultural practice.

The use of airplanes for dusting wheat fields has been suggested by several people. This suggestion seems worthy of consideration. Its practicability depends first of all, however, on the availability of an efficient insecticide and experimental proof that the fly can be controlled by its use. Apparently no tests of the more modern insecticidal dusts, such as the fluorine compounds, have been made on Hessian Fly. It is known that lime, Paris green, road dust, soot, salt (3,5) and sulphur have little merit. When we have discovered an efficient insecticide, the cost of application by airplane remains for consideration. The terrain in wheat regions would be generally favorable to its use. Although definite figures are difficult to obtain, experiments on other crops indicate that dusts can be applied by airplane for perhaps less than $3.00 per acre. An additional operation involving that much extra expense in producing the crop would be warranted only in the case of a severe outbreak. In that case, however, $3.00 per acre would not be prohibitive, and it is possible that this figure could be

reduced in practical treatment of large contiguous acreages. There is certainly a need for an effective control method which would be available after it is too late to apply the ordinary preventive measures and in circumstances where destruction of stubble and late planting are not applicable. Given a cheap and efficient insecticide, it seems possible that the use of airplanes might minimize the objections mentioned above to the point where the insecticidal method of control might meet this need.

2. Prevention of Larval Development.

While comparatively little information has yet been gained about this subject, some facts are known which point toward the practicability of preventing the development of the larvae after they have reached their feeding position. It is known that some wheat varieties are more resistant to the attempts of the larvae to feed than others and that this difference is probably due to biochemical or physiological rather than anatomical factors in the plants. Varieties of other crop plants also resistant to the insect pests of those crops are known. These facts open up the possibility that desirable fly-resistant wheat varieties can be developed in the same way that plant pathologists have produced disease-resistant varieties. Experiments indicating that fly-resistance may vary with the amount of silica present in the young plants have been reported by McColloch and Salmon (7). Again, by variations in the medium on which wheat plants are grown pathologists are able to modify the effect of fungous diseases on the plants. These discoveries point to the possibility that resistance to Hessian Fly may be induced by artificial changes in or additions to the food constituents available to the plants. All these considerations point toward the existence of biochemical phenomena which may be turned to practical use in the control, not only of Hessian Fly, but of other insects.

This biochemical method of control, as it might be termed, may be approached in four ways. (1) By breeding new wheats, with the present partially resistant varieties as a basis, more desirable fly-resistant wheats might be developed. (2) By determining through histological and chemical studies the specific characters responsible for fly resistance, the breeding of wheat possessing these characters would be much simplified, the compatibility of these characters with those necessary to productivity and quality would be known, and the possibility of strengthening these characters through the addition of suitable chemicals to the soil could be appraised. (3) By studying the effect on the larvae of varying the normal plant constituents, through the use of plants grown on synthetic cultural media, the possibility of fly control by means of suitable fertilizers might be determined. (4) By a search for some chemical assimilable by and harmless to the plant, but detrimental to the feeding larvae, it is possible that an insecticide applicable to the soil like a fertilizer might be discovered. These are all complicated and difficult procedures calling for cooperation of entomologists, agronomists, plant pathologists and biochemists. There is no certainty that any of them would lead to results of economic importance. On the other hand if these fields are not explored, facts of wide practical value may be overlooked.

Impractical Measures of Control.

Many expedients which have been suggested for the control of Hessian Fly are useless or of very doubtful value. The worthlessness of some of them, such as treatment of the seed, is too obvious to merit attention. Others are more plausible. Their weaknesses have been clearly brought out by McColloch (6). In the following remarks regarding impractical methods of control the quotations are from him.

1. Rolling.

"Many farmers urge the rolling of the field either in the fall or in the spring to destroy the fly. They argue that rolling will crush the eggs on the leaves and also the maggots and flaxseed at the crown of the plant. They do not realize that pressure sufficient to crush the various stages will also be injurious to the plant. The destruction of the eggs by this method is out of the question, since the period of oviposition may occupy a month or more, and this would necessitate rolling every few days."

2. Pasturing.

"One of the earliest methods advocated for the destruction of the fly, and one that is still held by many farmers, is the pasturing of wheat with live stock. The claim for this method is that the eggs will be destroyed by feeding and the larvae and flaxseed will be killed by trampling. If the life history of the fly is associated with the common practice of grazing, the futility of this method becomes apparent. As has been pointed out, egg-laying occurs early in the fall and during April and May. On the other hand the pasturing season is from the first of November to about the first of April. To pasture wheat at other times is detrimental to the crop. In order to prevent egg-laying it would be necessary for the plants to be kept eaten to the ground for several weeks. As for the crushing of the other stages by the hoofs of the stock, it must be remembered that during the winter the fly is at the crown of the plant an inch or more below the surface, and that trampling sufficient to destroy the fly would also injure the wheat plants."

3. Mowing.

"Among the earlier methods advocated for the control of the fly was that of mowing the wheat in the spring after the first brood had emerged and infested the plants. The object of this treatment was to destroy the larvae developing at the various joints, and also to remove leaves bearing eggs. The fallacy of this method is readily seen when we consider that a large percentage of the first spring brood develops at the crown of the plant. Mowing would also tend to delay harvest a factor, which would be favorable to the second spring brood."

4. Trap Planting.

The idea of using early-planted trap strips or decoy plots advocated by many writers is fallacious, as McColloch has pointed out. It is argued that decoy strips would attract the flies and induce them to oviposit before the main crop is up, after which the strips would be plowed under,

flies and all. This procedure implies delayed planting of the main crop. If the main planting is delayed until the flies have emerged, then the time of planting rather than the presence of trap plots is the factor responsible for the absence of fly from the crop. The adults are short-lived, and if they emerged before the main crop was planted, they would die before it attained sufficient growth for oviposition, whether the decoy strips were present or not. The trap plantings would thus be superfluous. Instead of preventing propagation of the early-emerging flies, they would provide for it, and even though plowed under would probably be a source of infestation later. If the main crop were out of the ground at the time the adults were abroad, they would not select the decoy strips in preference to it. The plants being smaller, they would probably be even more attractive to the flies than the earlier sown trap plantings. Therefore, whether the main crop were planted before or after the main emergence of flies, the decoy plots would not be a factor in preventing infestation. Not only would such trap plantings involve extra labor and expense, but they would serve only to propagate flies which in their absence might die without issue.

5. Burning the Stubble.

Burning the stubble before the flies have emerged from it was considered for many years to be an effective method of control. More recently the careful observations of many entomologists have brought out little to recommend the practice and much to condemn it. Burning destroys most of the puparia in those portions of the stems above the ground, but as a rule these puparia are only a minor part of the total number contained in the stubble, and a high proportion of them usually are parasitized. The majority of the live puparia are located close to the plant crowns, below the surface of the ground, where they are not injured by the fire. Moreover, there are usually patches of stubble which for one reason or another completely escape the flames. It has been observed repeatedly that burning of the stubble did not prevent plentiful emergence of adults in the burned-over fields and the consequent heavy infestation of the following crop of young wheat (3,8). There are also two agronomic objections to burning the stubble. It destroys valuable humus and it is not expedient in extensive regions where the common farm practice includes the spring sowing of clover in the growing wheat.

Practical Measures of Control.

1. Plowing-under of Stubble.

Since the flies pass the summer in the form of puparia in the wheat stubble, many of them can be eliminated at that time by plowing the stubble under so deeply that the adults cannot emerge. Thoroughly burying the stubble in this way has been found to reduce greatly the number of flies emerging from it (3,5). It has been proven repeatedly that adults can emerge through two or three inches of soil, hence deep and careful plowing, followed by cultural operations to pack the surface and close interstices, is necessary to the success of this method. It has been noted also that the earlier in the summer the plowing and cultivation were done,

the more effective they were in preventing fly emergence. Summer plowing and cultivation are not only valuable and practical means of minimizing greatly the number of flies emerging from stubble fields, but are approved by some agronomists as means of increasing yields of wheat planted on stubble ground and making late planting safer because of their stimulation to rapid growth (6). Drouth or extremely wet weather, however, limits the practice of summer plowing to some extent. Furthermore, although modifications of the rotation to allow the summer plowing of wheat stubble are practicable in some localities, they are incompatible with the standard wheat-clover-corn rotation of the Eastern United States where the clover is seeded in the growing wheat.

2. Destruction of Volunteer Wheat.

Volunteer wheat is one of the most important factors conducive to the propagation and perpetuation of the Hessian Fly. The same weather conditions which cause fly pupation and emergence also cause the germination and growth of volunteer wheat. Hence even though the planting of winter wheat is delayed until after fly emergence in the fall, the presence of volunteer wheat in the fields provides them a place to breed. It then serves as a source from which the planted wheat may become infested later. Parks (8) has reported that during the Kansas outbreak of 1916 spring infestation in planted wheat varied directly with the abundance of volunteer wheat in the fields the previous fall. The important role played by volunteer wheat in the recent Pennsylvania-Virginia outbreak has already been mentioned.

Destruction or prevention of volunteer growth is extremely desirable wherever it can be accomplished. This can be done by the same cultural operations used for eliminating the stubble. The destruction of volunteer wheat is subject to the same limitations as the plowing under of stubble, but by all means should be practiced wherever possible.

3. Rotation of Crops.

Stubble and volunteer wheat being the main source of flies infesting young wheat, it is obvious that, though they are able to migrate considerable distances, the farther from stubble the young wheat can be located, the less chance the flies have of reaching it. Observations have shown that where infestation of fields took place from nearby stubble, the infestation decreased steadily as the distance from the stubble increased. Rotation of crops to allow the planting of wheat as far from infested stubble as possible is to be highly recommended wherever the farming system will permit, particularly in regions where the more efficient control methods, such as plowing the stubble under and late planting, cannot be applied.

4. Stimulation of Growth.

Conditions favoring rapid, vigorous growth of young wheat tend to counteract fly injury. The plants are better able to sustain and recover from infestation, or if late planted, are able to secure a better start before winter. Thorough preparation of the seed bed, the use of fertilizers, and

seeding when conditions are favorable to quick germination, while they do not prevent infestation, all help materially in overcoming its adverse effects. This method of meeting the Hessian Fly menace is particularly important in regions such as California and the spring-wheat areas of Minnesota and the Dakotas.

5. Late Sowing.

Throughout the main winter wheat regions of the United States it has been known for many years that the later-sown wheat was usually much less infested by the Hessian Fly than the earlier-sown fields. The fact that in the majority of years emergence of the adult flies from the stubble takes place in late summer and early fall, and the fact that they survive only two or three days after emergence, makes it possible to delay the sowing of wheat until after most of the danger of fall infestation is past. There is usually a sufficient period for the completion of wheat sowing between the time the flies cease to emerge and the time when cold weather prevents further planting. It is not necessary to wait until complete cessation of fly emergence before wheat seeding can begin, and the sooner after the safe sowing date the wheat is planted, the better. The optimum sowing periods to escape both fly and winter killing due to extremely late sowing have been fairly well determined for the main winter wheat regions, and the application of this knowledge is one of the most valuable and universally practicable methods of preventing Hessian Fly injury.

Delayed sowing has its weaknesses as a method of escaping the fly and as a farm practice. In occasional years fall fly emergence is sufficiently delayed so that even the late-sown wheat becomes infested, though such late infestation is seldom serious, and cold weather may largely prevent the flies from maturing. Occasionally also weather conditions immediately following the safe sowing date may be unfavorable to seeding operations and rapid fall growth of wheat. Late-sown wheat is more subject to winterkilling, as has been strikingly demonstrated in the East-Central States in 1928. By waiting until the optimum sowing period to begin seeding the farmer cannot take advantage of such favorable weather for this work as may occur before that time, and the delayed wheat sowing may also interfere with the harvesting of other crops demanding immediate attention at that time of the year. These weaknesses, however, are not so serious as they may seem. If the farmer is to overcome the Hessian Fly, he must expect to make some adjustments in farm routine to this end. Extended experiments have shown that in the long run the best yields are obtained from wheat sown on or soon after the safe sowing date, and wheat growers who plan accordingly stand the best chance of escaping injury both from Hessian Fly and winterkilling.

6. Cooperation.

While much benefit may accrue to individual farmers from the use of the control methods now available, the full value of most of them can be secured only by their universal adoption throughout whole communities. If one farmer prevents infestation from originating in his own fields, his young wheat still may become infested by flies emerging from his neigh-

bors' fields, unless they too have taken steps to prevent it. Cooperation is necessary to the effective reduction of Hessian Fly outbreaks. Extension entomologists in several instances have developed and carried out workable plans for statewide control of the Fly with excellent success. Annual summer surveys are also made in many states to determine the abundance of the insect and the localities where extensive application of control measures is likely to be necessary. Cooperation in Hessian Fly control affords an excellent opportunity for the extension entomologist.

Conclusion.

As with most other insects, no single infallible panacea for Hessian Fly is known. Nevertheless, one or more ways of preventing or reducing injury are applicable wherever this pest occurs. Local conditions vary greatly in different parts of the United States and determine which of them can be used. The control methods now available are preventive rather than remedial. After a crop of wheat has become infested, no way is known by which it can be saved from the resulting injury. It is therefore particularly important that the proved preventive measures be regularly included in the farm routine or that the likelihood of Fly infestation be determined sufficiently in advance of the planting of the crop so that the farmers may be warned in time to include them. It must be admitted that the present methods of Hessian Fly control are not ideal. There is a real need for more certain and effective measures that are less subject to the whims of the weather. At the same time, losses due to the Hessian Fly can be largely prevented by the use of those measures now at our command.

Literature.

1. Encyclopedia Britannica. 3rd Ed. Vol. 8 (1797), pp. 488—495.
2. Fitch. Asa, The Hessian Fly; Its History, Character, Transformations and Habits; in Trans. N. Y. State Agr. Soc. Vol. 6. 1846, pp. 316—373, illus.
3. Headlee, T. J., and Parker, J. B., The Hessian Fly; in Kans. Agr. Expt. Sta. Bul. 188 (1913), p. 138, illus.
4. Hill, C. C., and Smith, H. D., Status of the Parasites of the Hessian Fly *Phytophaga destructor* (Say), in Pennsylvania, Maryland, and Virginia; in Journ. Agr. Research, Vol 36 (1928), No. 2, pp. 151—155.
5. Osborn, Herbert, The Hessian Fly in the United States; in U. S. Bur. Ent. Bul. 16, n. s. (1898), p. 57, illus.
6. McColloch, J. W. The Hessian Fly in Kansas; in Kans. Agr. Expt. Sta. Tech. Bul. 11 (1923), p. 96, illus.
7. McColloch, J. W., and Salmon, S. C. The Resistance of Wheat to the Hessian Fly. — A Progress Report; in Journ. Econ. Ent. Vol. 16 (1923), No. 3, p. 293—298.
8. Parks, T. H. A County-wide Survey to Determine the Effect of Time of Seeding and presence of volunteer wheat upon the Extent of Damage by the Hessian Fly; in Journ. Econ. Ent. Vol. 10 (1917). No 2, pp. 249—253.

The Utilization of Entomophagous Insects in the Control of Citrus Pests.

Professor Harry S. Smith,

Entomologist, Citrus Experiment Station, University of California, Riverside, Cala.

Citrus insects appear to be particularly favorable subjects for biological control, especially in the larger Citrus growing districts of the world. This is due primarily to the fact that in these districts the major pests of Citrus are not indigenous, but have largely been introduced, and it is a well recognized principle in biological control that introduced insects are more likely to yield to this method than are native ones. The reasons for this are, of course, perfectly obvious. In most of the great Citrus growing areas of the world the genus Citrus itself is an introduction, and with few exceptions native insects have not been inclined to favor greatly this exotic plant group as a host. In California only two species believed to be native, *Tortrix citrana* and *Scirtothrips citri,* are of commercial importance. All other major pests of Citrus are definitely known to be introduced species. This is also true, although perhaps to a lesser extent, in other Citrus growing regions of the world, and interestingly enough, the major pests of Citrus are largely the same insects throughout the world. *Chrysomphalus aurantii, C. dictyospermi, C. ficus, Lepidosaphes becki, Saissetia oleae, Dialerodes citri,* and certain species of *Pseudococcus* are the principal pests of Citrus toward which most of the control work is directed. While all of these insects do not occur in all of the Citrus regions, at least several of them are found in each. There is, therefore, a community of interest among the Citrus entomologists of the world, and no phase of insect control provides a better opportunity for international cooperation than does the application of biological control to these insects. It is hoped that one outcome of this Congress will be a definite program for such cooperation.

Another reason for the favorability of Citrus insects for attack by the biological control method is the fact that they are practically all scale insects. This group, or so the writer believes, lends itself especially well to biological control. The principal reasons for this believe are, (1) that they are particularly vulnerable to attack by entomophagous insects in all stages, since they are without special protection and without means of escape; (2) that they are sedentary and easily visible, rendering colonization of enemies easy; and (3) that entomophagous insects form a relatively very important part of the composition of the environmental resistance to which they are subject, considering the group as a whole, although there are important specific exceptions to this as will be noted later. Alongside these natural factors which are favorable to the application of this method

is the economic one, that the cost of artificial control is very high, amounting often to $50.00 or more per acre. This serves as a stimulus to entomologists to interest themselves in this type of control, and also tends to influence those engaged in the industry to demand liberal support for the necessarily expensive exploration and research.

The history of biological control, so far as it relates to Citrus pests, begins with the introduction of the *Vedalia* into California in 1888. The host insect, *Icerya purchasi*, had been accidentally introduced into the San Francisco Bay region on Acacias nearly 20 years before, had finally reached the Citrus growing sections of Southern California and had become a terrible plague to the Citrus growers by 1886. One who has never seen a Citrus tree severely infested with this pest cannot conceive of the damage this insect can do. I have seen sugar deposited on the leaves to a depth of more than an eight of an inch, crystallized from the honeydew secreted by these scales. It is not surprising that the growers became alarmed and that the bankers refused to make loans on infested property. An appeal to Washington was made, as it appeared certain that the industry was ruined unless a remedy was speedily forthcoming. One of the results of this appeal was the despatching to Australia of Albert Koebele to gain information on the natural control factors operating against the scale in its natural habitat.

The officials of the U. S. Bureau of Entomology, especially Dr. L. O. Howard, had been in correspondence with entomologists in Australia and had determined that the cottony cushion scale was not known there as a pest. The information had been obtained that the scale was parasitized by the little fly, *Cryptochaetum iceryae* Willist. It was primarily for the purpose of securing this parasite that Koebele was sent to Australia, although, of course, he had instructions to forward such other insect enemies as were encountered. Immediately upon his arrival he found the *Vedalia*, which he made preparation to ship to Coquillet, who had been instrusted with the receiving end of the project in California. Shipments of *Cryptochaetum* were also made at the same time. As is well known, both of these insects found conditions in California to their liking, and within 18 months after their introduction the cottony cushion scale was in complete subjection, and has remained so ever since.

The *Vedalia* is much the more conspicuous of the two insects and has received practically all the credit for the remarkable outcome of this first successful attempt at biological control. It is a fact, however, that under some conditions *Cryptochaetum* is more effective than the *Vedalia*, although in general this is not the case. Riley wrote in 1889 ". . the *Lestophonus (Cryptochaetum)* for the present has been overshadowed by the *Vedalia*, but its importance has not yet been appreciated". It would be interesting to know just what prompted Riley to make this statement, but his confidence in *Cryptochaetum* it seems to the writer has been fully justified by later events.

It must be admitted that in no other case has biological control of a major pest been so perfect as in that of *Icerya*. It is the criterion by which most biological control projects are judged, but this should not be so, because of the exceptional conditions which apply. It is interesting to speculate on the reason for this remarkable success. The cottony cushion

scale, contrary to the general belief, does not have an unusually high reproductive capacity. There is scarcely more than a single generation per year, although one may find practically all stages at any time, making it appear to have several. Its development is extremely slow, it requiring six months or more from egg to egg even in the insectary. The young scales do not seek crevices in bark or other seclusion, hence are always vulnerable to attack. The *Vedalia*, on the other hand, is very active and prolific, going through many generations to one of its host. Its increase is not checked by lack of synchronization between its life-history and that of its host, since there are some egg-sacs available at all times. None of our native parasites attack *Vedalia*, and it is not therefore suddenly checked in its propagation when it becomes abundant, as is so often the case with native ladybirds, and it invariably reaches a point where it simply overwhelms its host by sheer numbers. The biological factors which explain the success of *Vedalia* are its relatively much greater reproductive capacity, the invariable accessibility of the host and the comparative freedom of *Vedalia* from environmental resistance other than starvation. In no other case of biological control known to me are all these factors so favorable to success. There are few, if any, entomologists who believe that the low numerical status of *Icerya* is due to any factors other than biological ones. Any doubters can readily convince themselves by screening infested trees to exclude the *Vedalia*, or by spraying infested trees with arsenicals, which protects the egg sacs from *Vedalia* attack. *Icerya*, free from attack by *Vedalia* and *Cryptochaetum*, will practically destroy its host within a year.

The black scale *(Saissetia oleae)* is no doubt properly considered the major pest of Citrus in California, although in other leading Citrus districts of the world it seems to be of lesser importance. The enormous cost of controlling it by artificial means in this state, and the tendency toward resistance to cyanide which it is now exhibiting, have made it a particularly attractive subject for biological control experimentation. Many different exotic species of entomophagous insects have been introduced into California to prey upon this pest, yet its control by the biological method is still far from an accomplished fact.

The first and most important predator of *S. oleae* is the Coccinellid *Rhizobius ventralis*, introduced by Albert Koebele from Australia about 1895. It is thoroughly established throughout the State and without question exerts a beneficial influence particularly along the coast. Like many other scalefeeding Coccinellids, it thrives best in heavily infested groves, and once a Citrus grove gets in this condition, *Rhizobius* will almost invariably become extremely abundant and clean it up. From a practical standpoint, however, no grower can afford to let his grove get into this condition. Long before it reaches that point it is sprayed or fumigated, and under such conditions the Coccinellid is ineffective. Although a very efficient insect under certain conditions, it must be admitted that *Rhizobius* does not fill a very important place in the pest control program as carried out in California at the present time. It has promise, however, as a subject for mass propagation and distribution.

The next event in the attempt to apply the biological control method to the black scale in California was the introduction of the Chalcidoid

Scutellista cyanea Motsch. from South Africa in 1902. This work was carried out by Dr. L. O. Howard, of the U. S. Bureau of Entomology, Mr. C. P. Lounsbury, of the S. African Department of Agriculture, and Alexander Craw, of the California Horticultural Commission. It was thoroughly distributed over California and is now found commonly wherever the black scale occurs. For a time it did most effective work, but, as is often the case with introduced parasites, when it finally had completely adjusted itself to its new environment, its numerical status was much lower than it had been during the first two or three years after its introduction. Hence its promise of completely effective control of its host was not fulfilled. The reduction of its status was due to the severe attack of the predatory mite *Pediculoides rentricosus* and of certain secondary Chalcidoid parasites which occurred in the California fauna prior to the introduction of *Scutellista* and which subsisted on parasites of *Lecanium hesperidum* and perhaps other scales. *Scutellista* deposits its eggs beneath the body of the host, and the larvae feed upon the eggs in the cavity. Often the eggs are so numerous that the parasite larva reaches maturity before all the eggs are consumed; therefore a high percentage of parasitism does not by any means assure that there will not be a large hatch to re-infest the tree.

The last important and perhaps most valuable introduction of entomophagous insects to destroy the black scale was *Aphycus lounsburyi* Howard, a chalcidoid parasite native of South Africa, but which it happens was actually introduced from Australia. This valuable parasite was established in California in 1918 and was soon distributed in all the infested districts. It was first colonized along the coast and did such remarkable work that many thought the black scale problem was solved. Orchards were thoroughly cleaned up and in some cases fumigation was discarded. At the end of about two years, however, the local secondaries began to appear in the orchards in great abundance and the efficiency of *Aphycus* was rapidly lowered, until it again became necessary to undertake control by mechanical means. The possibility of this was foreseen, but it was hoped that the secondaries, after their first rapid increase, would also lessen in effectiveness, and that when a condition of equilibrium was finally reached, the status of the black scale would have been lowered to a point where its economic importance was at least greatly reduced. It is evident now that this will not happen, and it will still be necessary to rely largely on artificial control. One very beneficial effect of the introduction of this parasite, however, has been the "evening up" of the black scale hatch, so that it is possible to "time" fumigation and spraying much more effectively now than formerly. From this standpoint it has accomplished a great deal of good.

Saissetia oleae has a quite different life-history in the interior of Southern California than on the coast. Here, there occurs a single uniform generation of the scale each year, whereas on the coast there is a great deal of overlapping, so that one may find practically all stages of the scale at any season. As was predicted, this condition had a pronounced effect on the behavior of the parasite. Like most scale parasites, *Aphycus* must go through several generations per year, and must, therefore, find suitable hosts to carry it through these several generations. This it is able to do on the

coast, but in the interior there is a long period, from about the first of August until February, when there are practically no scales sufficiently large to serve as hosts. The result of this is that the parasite each year becomes scarce almost to the point of extinction. It is carried over this period on the few "off hatch" scales which occur on ornamentals and young Citrus trees, but in such small numbers as to preclude its bringing about control of its host.

As to the final outcome of this attempt, nothing definite can be predicted. Two distinct problems present themselves. Along the coast the question of synchronization does not enter in, but the secondaries there are so generalized in habit that they appear capable of attacking and destroying almost any species of primary parasites which can be discovered. *Quaylea* for example is not limited to internal parasites, but destroys as well such parasites as *Scutellista* and *Tomocera*, which feed upon the eggs beneath the parent scale. It does not attack the very small parasites such as *Coccophagus*, but for some unknown reason these insects are not particularly effective in the orchards, although they are in the insectaries.

In the interior, lack of synchronization is the obstacle which must be met. Apparently what is needed here is a parasite which has a single annual generation corresponding with that of its host. There are many such parasites of scale insects, a good example being *Encyrtus fuscus*, which deposits its eggs in the newly hatched *Lecanium corni* in May and June. These scales reach maturity during the following year, the parasite reaching the adult stage at the same time as the young scales hatch. Although we have studied 52 different species of black scale parasites, we have not yet found one attacking this host which has such habits. There are many parts of the world which have not yet been explored for this purpose, and such a parasite may yet be found.

The biological control of the black scale through mass production of some of the enemies already available has not yet been seriously attempted, but it gives some promise.

The Diaspine Scales.

Among the most important pests of Citrus throughout the world are the diaspine scales of the genera *Chrysomphalus* and *Lepidosaphes*. While these insects are attacked by several species of parasites, a high percentage of parasitism seems to be rare. Occasionally in untreated groves parasitism reaches a maximum of around 40%, but where regular control measures are practiced a 10% parasitism would be higher than the average. The principal parasites are *Aphelinus chrysomphali* and *Aspidiotiphagus citrinus*. In Japan and China *C. ficus* and *C. aurantii* are attacked commonly by the Encyrtid *Comperiella bifasciata* Howard. When introduced into California this parasite readily oviposited in *C. aurantii*, but the eggs and first stage larvae were immediately killed by phagocytosis. It became established, however, on *C. ficus*. In those countries where the latter is a Citrus pest of importance, *Comperiella* should be introduced. *C. ficus* does not attack Citrus in California.

There occur in the world many species of *Coccinellidae* which attack these Diaspines, but as is usual with predators, they do not become efficient

unless the trees are permitted to become heavily infested, which is disastrous. Among the most important of these Coccinellids are *Lindorus lophanthae, Chilocorus bivulnerus, C. bipustulatus, C. kuwanae, Exochomus quadripustulatus, Orcus chalybeus* and *O. australasiae.* Of these species only *C. bivulnerus* is indigenous to California, but the others have been introduced and some of them established. *Lindorus* merits consideration from the mass production standpoint.

The Mealybugs (Pseudococcus spp.).

There are few if any important Citrus growing districts of the world in which the common mealybug, *Pseudococcus citri,* does not occasionally become abundant enough to do economic injury. California has been no exception, this insect having been a pest of more or less seriousness since 1880. The first attempt at biological control was the introduction into California of the Coccinellid *Cryptolaemus montrouzieri* from Australia by Koebele in 1892. This beetle became established at that time and has persisted ever since in the coastal areas. As mentioned before in connection with other predators, this ladybird often became abundant after a grove had become heavily infested and did a thorough job of cleaning up, after the damage had been done. Considerable loss was incurred from year to year and in 1914 a collector was sent to Sicily to search for additional natural enemies. A result of this expedition was the introduction into California of the Encyrted parasite *Leptomastidea abnormis.* This insect did very efficient work, but in spite of it there were occasional outbreaks. In the propagation of this parasite in the laboratory it was found that mealybugs could be grown on a large scale on potato sprouts. This knowledge led to the attempt to produce the ladybird *Cryptolaemus* on a quantity basis in the insectary for orchard colonization, and the first large scale experiment to control the mealybug by this method took place in Ventura County in 1918. The work was completely successful and expansion took place rapidly. Prior to this the so-called Citrophilus mealybug *(P. gahani)* had appeared in Southern California in the Citrus groves in 1913. An attempt was made to eradicate it, but this was unsuccessful, and spread into clean areas took place with rapidity. This species proved to be a far more serious pest than *P. citri* had ever been. It was not attacked by any of the native parasites of mealybugs and it had a very high productive potential. Fortunately for the growers, biological control through the mass production of *Cryptolaemus* seemed to be nearly as effective against this pest as it had proven to be against the common mealybugs. The Citrophilus mealybug has continued to spread until at the present time there are approximately 50,000 acres of Citrus infested, and it will apparently be only a short time until the entire acreage in California has been invaded, although in the hotter interior sections it has not proven serious. The mass production of *Cryptolaemus* has kept pace with the dissemination of the pest and at present there are fourteen propagating plants in operation for this purpose. The largest of these, that of Orange Country, consists of eighteen buildings, each 14 by 70 feet in area. The total production during the past year was over 40 million beetles, at a cost of between ¼ and ½ cent each. The total inventory of buildings

and equipment amounts to approximately $150,000 and operating expenses during the past season ran in the neighborhood of $125,000. A local fruit growers association in Ventura County has recently raised a fund of $60,000 for the purpose of building a new insectary.

These insectaries are operated by the county governments, the local fruit growers' associations and by some of the large ranches.

On the whole this work has proven very successful, although it is not yet perfect and there is much to be learned about this type of pest control. During the past two seasons there has been some difficulty in certain restricted localities, where *Cryptolaemus,* although colonized in considerable numbers, has not been able to keep the pest below the point of economic injury. The weather has been cool and it appears that this has been sufficient to retard the rate of development of the Coccinellids, although it has not had a similar effect on the mealybug which is an insect that thrives best during the cooler portions of the year. It has not been definitely proven that this lack of satisfactory results is due to weather conditions, but at any rate it creates an interesting problem in biological control which we are endeavoring to solve.

Cryptolaemus is not normally active during the rainy season and at the same time the mealybug is able to increase slowly, so that in the early spring a heavy hatch occurs which, if not taken care of, causes a dropping of the fruit. During the winter the mealybugs occur as isolated individuals on the trees and under these conditions predators are not very effective. It has been realized, or believed, for a long time that an efficient internal parasite might effectively destroy these isolated specimens in such a way as greatly to lessen the spring hatch. For this reason our foreign collectors have always been instructed to be on the lookout for the Citrophilus mealybug in the hope that its country of origin might be located and such parasites be found. Clausen searched for it thoroughly in Japan, China and the Philippines, and Silvestri covered the same territory without success. It seemed likely that it must have arrived in California through the Golden Gate, from some country maintaining direct steamer connections with San Francisco. Failure to locate it in the above countries induced us to try Australia and it was discovered by one of our collectors, Mr. Harold Compere, at Sidney, N. S. W., in September 1927, under such conditions as to warrant the conclusion that it was native there. Six species of entomophagous insects were found attacking it, as follows: two internal Hymenopterous parasites, *Tetracnemus* n. sp. and *Coccophagus* n. sp.; two Coccinellids, *Pullus* sp. and *Diommus* sp.; a *Chrysopa* and a species of *Diplosis.* All of these insects were successfully transported to California and all are being propagated in quantity and colonized in the orange grove. With these new enemies available the situation with regard to the Citrophilus mealybug appears to be very hopeful.

In conclusion the writer would like to state his belief that there is a wonderful opportunity for Citrus entomologists throughout the world to render a great service to the industry through cooperation along biological control lines. With practically a single host plant, attacked by scale insects, most of which are common to all the leading Citrus producing areas of the world, but which themselves are attacked by different entomo-

phagous insects in each country, it would seem that exchange of information and material could be made of inestimable value. It is obvious, of course, that strict precautions would have to be taken from a quarantine standpoint, and the work would necessarily have to be carried on by competent entomologists; but given these conditions there is no doubt but that the cost of Citrus pest control could be greatly reduced by a greater extension of the biological method. The first step toward this end is for the Citrus entomologists to undertake to obtain accurate and detailed information regarding the entomophagous insects attacking Citrus scales in their own countries. By fostering such studies, the International Congress of Entomology can achieve very definite results of practical value.

Fly Attack and Animal Colouration.

Professor S. Hadwen, University of Saskatchewan, Saskatoon, Canada.

(With 2 text-figures.)

In the study of animal parasites it seems almost impossible to formulate laws which govern their behaviour. In fact, each parasite seems to be a law unto himself. The following observations will, it is hoped, exemplify this point.

It would appear that Darwin was the first to draw attention to the colouration of animals in relation to fly attack. Darwin referred to white cattle. However, he did not specify what species of flies caused them more harm than the darker coloured animals.

The writer wishes to refer to two articles he has written on this subject in 1922 and 1926, in which he has shown that certain species of flies parasitize white animals more than the dark skinned. In some cases, it is because white beasts suffer from the effects of sunlight, they wander about in a listless manner with their eyes partly closed, and are consequently less resisting to insects. White reindeer attacked by Warble Flies, *Oedemagena tarandi* L. and *Cephenomyia trompe* Modeer, furnish a good example of this fact.

In the case of domestic cattle, other insects show a preference for white, notably lice, the *Trichodectes* and *Haematopinus*. Just recently the writer saw a white albinotic Shorthorn calf in a pen together with some darker coloured calves. The white calf had been treated several times for lice, but he was still heavily infested, while his stable companions seemed entirely free. Mange mites also seem to find white skins more suitable for a habitat than dark skins. This is especially noticeable in white pigs.

The reason for this does not seem to be connected at all with outside factors, such as temperature, but rather to the fact that white skin is lacking in certain cellular elements, the melanoblasts. These cells occur in the malpighian layer and are pushed up to the corneum, where they are cast off in the form of scurf. It is probable then that albinotic skin is not as strong as pigmented skin, and owing to the absence of the pigment cells, somewhat thinner.

Sunshine and heat inhibit the growth and reproduction of some species of mange mites; for instance, the psoroptic and chorioptic forms, and also lice. In Canada these parasites are mainly active during the dark winter months. In this instance, the parasites are near the surface of the skin, but in the sarcoptic and demodectic mange, the mites burrow deeply and escape the harmful effects of the sun's rays.

Resistance on the part of the skin to the penetration of the sarcopts is a most interesting example of what the epithelial layers are able to do

in protecting the body against insect attack. In a recent work, Besredka, 1927, has shown the wonderful defence which the skin offers to bacterial invasion. Here is an instance in which the skin resists parasitic attack and also bacterical invasion. This is easily proved by examining a case of sarcoptic mange, even a very advanced one. Pus formation is not usual in such instances. In fact, the common name for sarcoptic mange is dry mange. The exudate which oozes out and forms crusts on the surface of the skin must possess some qualities which inhibits or kills the pus forming cocci which are always present on the surface of the skin.

The difference between follicular and sarcoptic mange is that in the former the mites burrow below the protecting epithelial layer and consequently are not subject to its defensive reactions.

Animal Parasites and Sunshine.

From the above it is clear that some of the smaller parasites shun the sunlight. The larger forms may do so likewise. *Rhipicephalus evertsi*, the red legged African tick, prefers such situations as the hollow open space under the tail, and *Hippobosca equina* does the same. Other ticks crawl under the thicker parts of the hair. Tabanids are sun loving insects as a rule, but the writer knows one or two species, like *Tabanus fratellus*, which invariably seek the shade of the abdomen. The difficulty in deciding whether these habits are for the object of securing shelter or otherwise cannot be decided entirely by what one sees. The thickness of the skin may have to be taken into account, or its porosity, and again the length of an insect's mouthparts. The *Amblyomma* ticks having long hypostomes may anchor themselves to parts of the body where the integument is very thick, for instance on the legs.

The Hypodermas lay their eggs on the thinnest and most porous parts of the skin to facilitate the penetration of the larvae.

Graybill, 1914, mentions *Liperosia irritans*, the horn fly, which according to several observers, rests on dark coloured hair in preference to the light. The writer has noted several peculiarities about horn flies in which they differ from other insects. Horn flies will accompany cattle into a stable and remain on them for hours at a time. This is quite a different habit from other flies, which usually avoid the darkness and shade of buildings. Such flies have been noticed resting on the white haired portions of the skin. This is in contradiction to Greybill's statement, but, no doubt, the observations he records were made out of doors.

Another peculiarity of horn flies is that, when they are resting on the hairs, they invariably settle near the free ends of the hairs with their heads pointing outwards. This habit places them as far from the body heat as it is possible for them to get, and exposes them to the full force of the light. The effect of sunlight on the hair must also be taken into consideration in this problem of colour and fly attack. Black hair absorbs more heat than does white, but is does not reflect the heat like white hair. The writer has shown that white skin covered by white hair is very apt to become sunburned, whereas black skin covered by black hair escapes this form of injury.

From this, it is evident that the insects which follow animals have extraordinary powers of detecting and benefiting from conditions of temperature which we ourselves are unable to detect. The only explanation the writer can give for the hydrophobia exhibited by the Warble-Fly of cattle, *Hypoderma bovis,* when the animals it is chasing run into water, is because the fly immediately detects the moisture laden atmosphere above the water, which for some reason is adverse to its well being. Perhaps this explanation is wrong, but it gains support from the fact that *Hypoderma bovis* is never on the wing until the sun has become hot and it is not seen in wet weather. Other near relatives are not so easily deterred by moisture or cold. Oe. *tarandi* being a Northern insect has adapted itself to both moisture and to cold. Linnaeus records having seen one of these flies exhausted after egg laying, resting on a snow bank high up on a mountain in Lapland. The writer has seen flies ovipositing on reindeer in a corral which was covered with water, and when the insects had finished laying, they often settled on lumps of mud which rose an inch or two above the surface of the water.

It must be mentioned that Northern insects are often more hairy than the Southern forms.

All these differences in habit are worth recording from an economic point of view, and though it may seem a little "far fetched", some day we may see cattle protected from *H. bovis* by a system of fine water sprinklers.

In conclusion it would appear that the parasites of animals have few habits which are in common, and if comparison be made between the members of one single family, for example the *Oestridae,* it is even hard to believe that there is any relationship between them, so different are they in appearance. It would seem probable that they have been grouped together simply because they are all parasites of animals.

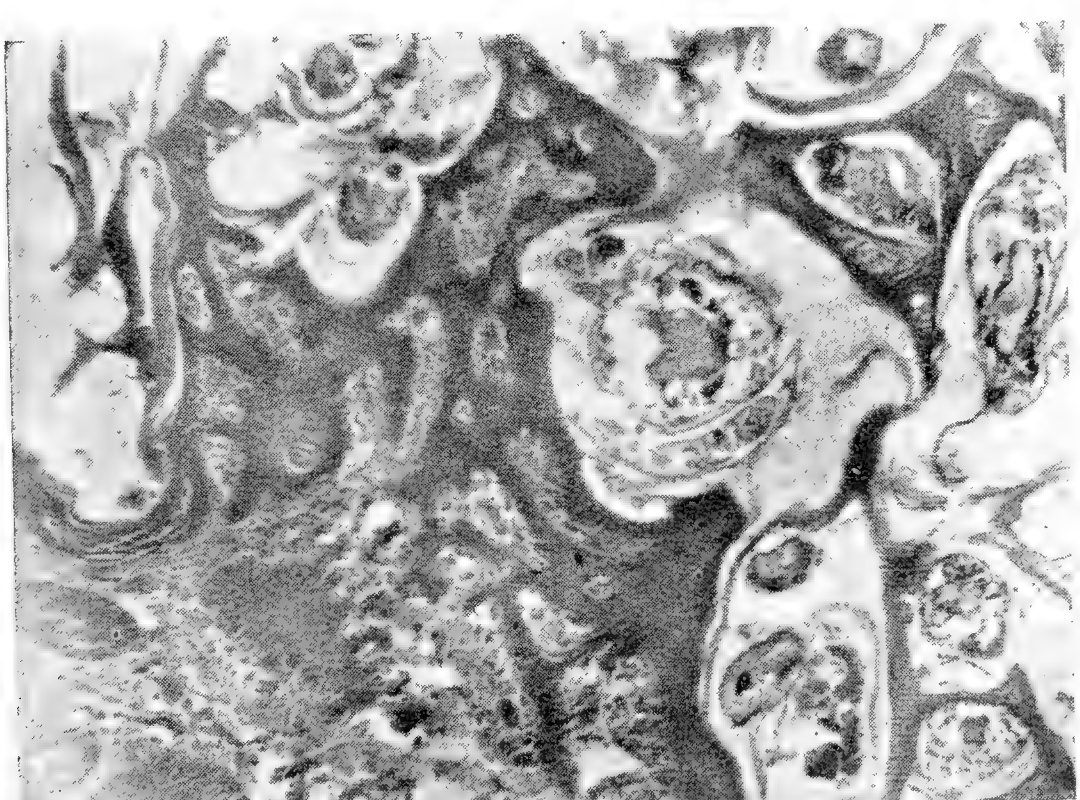


Fig. 1.— Sarcoptic mange in a pig. --- Bodies of Mites cut across. The epithelium grows fast enough to prevent the mites reaching the subcutis.

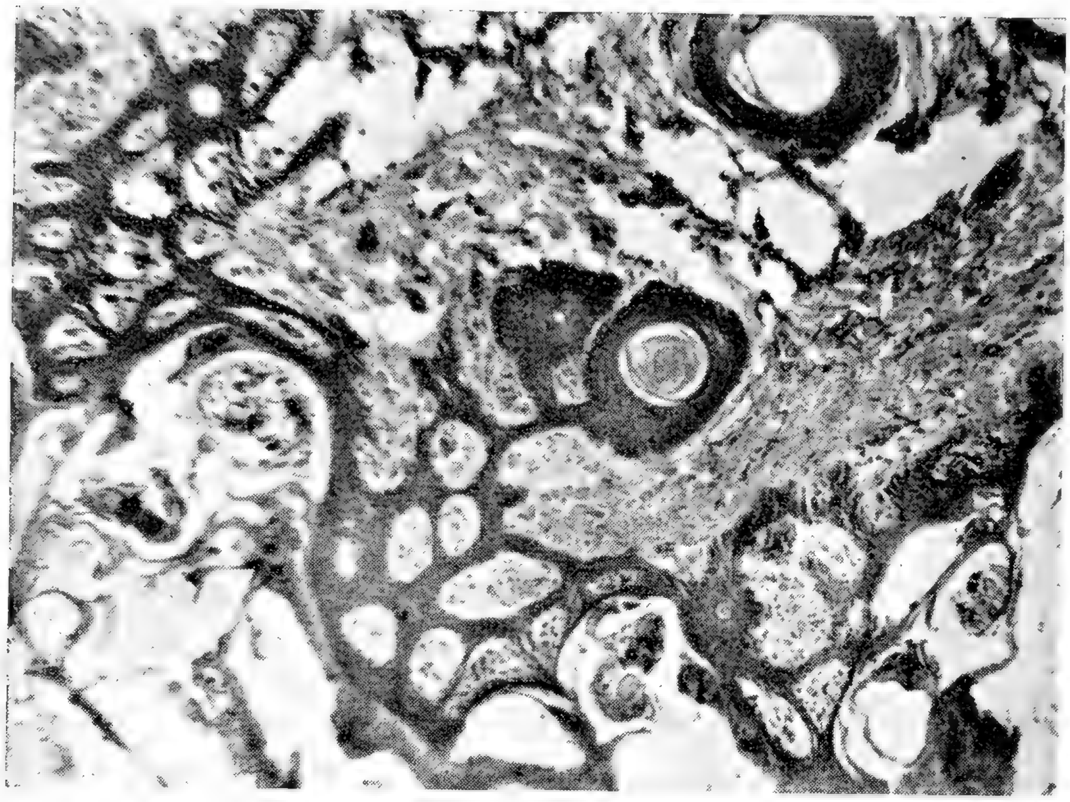


Fig. 2. — Sarcoptic mange in a pig. --- Note proliferating epithelium resisting the pene-ration of mites. In the centre is a pearl. Pearls are commonly seen in skin cancers. They are evidently formed from isolated bits of epithelium, the cells of which keep on growing, those in the centre become come compressed and form concentring rings.

References.

Hadwen, S. 1926. Notes on the Life-History of *Oedemagena tarandi* and *Cephenomyia trompe* Modeer. Journ. of Parasitology. Vol. XIII, No. 1, pp. 56—66, 2 figs.

— S. 1926. Color in Relation to Health of Wild and Domestic Animais. Journ. of Heredity. Vol. XVII, No. 12, pp. 450, 461, 8 figs.

The Control of Stored Grain and Flour Mill Insects.*)

Professor Geo. A. Dean, Entomologist Kansas State Agricultural College, Manhattan, Kansas, and Gilbert Schenk, Associate Entomologist, Bureau of Entomology, U. S. Department of Agriculture, Washington, D. C.

(With 2 text-figures.)

The control of insects infesting stored grain and milled products is a problem in which man was vitally interested long before economic entomology was known as a profession. In fact, from the earliest history of civilization, efforts have been made to protect grain and food products from the ravages of insects. While great progress has been made in the development of control measures, the problems, due to the tremendous increase in the production, storage and transportation of grain and milled products, have become more difficult. Also, the keen competition of the bakeries and the strict requirements of the flour brokers and the general public, that flour and all milled products used for human comsumption must be delivered in a sound condition and free from insect infestation, have presented problems that call for the most careful investigation of the scientist and the closest cooperation of the many interested concerns.

The losses caused by insects injurious to stored grain and milled products are tremendous. While there are no accurate data available on the total amount of the losses in the United States, it frequently is estimated that they are about 5 % of the total value of the products, which would amount to about $200,000,000 annually. However, the sum, enormous as it may be, gives no adequate idea of the real situation, for it does not take into consideration the reputations of the milling company, the flour broker or baker, whose well established brands of products have been damaged by the presence of insects.

PART I. CONTROL OF STORED GRAIN INSECTS.

A. Preventive Methods.

On the Farm. — Many do not realize that the rice weevil and the Angoumois grain moth, which are the two most serious insects infesting wheat, corn, rice, grain sorghums, and other cereals, attack the grain not only while it is in shock and stack in the field, but may also infest the standing grain before it is harvested.

In order that infestation in the shock and stack may be avoided, the grain should be threshed as soon after harvesting as practicable. If it has

*) Contribution No. 370, from the Entomological Laboratory, Kansas State Agricultural College.

remained in the shock or stack very long, it should be fumigated with carbon disulphide soon after it has been stored in the bin or granary.

Every farmer knows that the fag-end of the previous year's crop is very likely the portion most badly damaged by insects, and thus fresh grain should not be exposed to attack by being placed in bins or granaries with that already infested. Before storing the new crop, the old grain should be removed and the floors, walls and ceilings of the bins thoroughly cleaned. If the granary has been badly infested, it should be fumigated before the new grain is stored.

A common practice on the farm is to store bran, shorts and other milled feeds in the granary. Even cleanings from the cleaning rooms of the mill or sweepings from the mill may be purchased. These products are almost sure to be badly infested. Sometimes there is opportunity to purchase, at a reduced price, damaged or infested flour and meal. Since the storing of such products and other feeds in the granary is one of the main sources of insect infestation, these infested feeds should not be stored in the same building where grains are stored.

Inasmuch as cleanliness is very important in the prevention of infestation, all dust, dirt, rubbish, refuse grain, flour, meal and bran, which serve only as breeding places, should be removed. Granaries, as far as possible, should be constructed so as to be easily kept clean, and in such a manner as not to allow accumulations to collect and afford lurking and breeding places for insects.

Granaries should also be constructed so as to avoid dampness and heating of grain. This dampness, which induces a condition in the grain termed "heating", is conducive for a rapid increase in insect life, unless the temperature caused by the heating reaches about 100° F, or more, which then will retard development and if it reaches about 115° F, will cause the death of the insects. It is also a well established fact that when insects, such as the rice weevil and the flat grain beetle, are abundant in grain, they will cause a decided rise in temperature.

A liberal use of air-slacked or hydrated lime is recommended for dusting in corners and along the edges of bins. This lime should be dusted in the bins as soon as they are empty, but removed before storing the grain.

If corn is showing infestation in the open crib, it should be shelled at once, and, after it is stored in tight bins or in the granary, should be fumigated with carbon disulphide.

In Grain Elevators. — Since the refuse grain, which may accumulate in elevators, serves only as breeding places for insects, cleanliness as a means of prevention of insect infestation cannot be over emphasized.

Fresh grain should not be exposed to attack by being placed in bins that are already infested.

Before grain is stored, the bottoms and sides of the bins should be thoroughly cleaned or, in the case of deep bins or silos, it would be more practical to fumigate the empty bins with hydrocyanic acid gas. The refuse grain and the other materials which collect on machinery and accumulate in and about the dump, along the conveyor tunnel, and in the

elevator pits, should be removed and burned. The elevator pits or wells should be treated frequently with a fumigant or some material to destroy the insects.

All grain brought into the elevator, either in cars, wagons, or trucks, should be carefully examined for insect infestation and, if infested, should be stored in quarantine bins where it can be fumigated or heated in a dryer.

Shifting and Cleaning of Grain. — If the grain is infested by the grain or meal moths, the frequent agitation or shifting of the grain from one bin to another will destroy many of the insects, because the adults are unable to free themselves from very deep down in a mass of grain. The passing of the grain through a cleaning or a fanning machine will remove a large number of the insects feeding externally on the grain. However, this process will not remove the kernels infested by the larvae of the Angoumois grain moth, the grain weevil, rice weevil, or grain borer, which pass their entire larval life within the kernels. The insects, screened out or removed by the cleaner, must be killed or disposed of or they will soon become distributed throughout the bins of the granary or elevator.

Freezing of Grain. — Exposing the grain, or removing it from one bin to another so that it will fall through the air in zero weather will frequently cool the grain to a sufficiently low temperature to cause insect activity to cease. The effectiveness of this method depends not only upon the manner of the exposure to the cold weather, but also upon the opportunity for the grain to become warm again, in which case the dormant insects will again resume activity.

Heating of Grain. — A temperature of from 125° to 140° F maintained for a few minutes will kill all stages of grain infesting insects, provided the grain is passed through the heat cylinders or chambers in such a manner that the heat will have ready access to the kernels of grain. Goodwin's experiments (1922, p. 3) show that wheat, after being subjected to 150° F for two hours, germinated as well as untreated wheat from the same lot. Peas and beans were heated to a temperature of 140° F for twenty minutes and apparently were uninjured, since they germinated well. Corn heated to a temperature of 140° F for almost two days, germinated almost as well as the unheated sample from the same lot. Experiments of several other investigators also show that grain heated to temperatures sufficiently high to kill all insect life will not injure the grain for milling or for planting.

Due to the lack of satisfactory heating apparatus or the difficulty of subjecting the grain to the proper temperatures, the heat method is chiefly used by millers and large grain dealers whose plants are equipped with commercial driers suitable for the purpose. The writers believe that the possibilities of heat as a practical and an effective means of controlling grain-infesting insects are very promising, and that suitable apparatus or appliances will be developed whereby grain can be treated with heat on a smaller scale that that by the large commercial driers. For several years the heat method has been used extensively in the United States, Egypt, and other foreign countries, for treating seeds.

One type of a heating unit which is in use in some parts of the United States for the treatment of wheat, consists of an upright steel cy-

linder which may be heated to a temperature of from 125° to 150° F. by either blowing hot air in at the base of the cylinder or heating it by steam radiation at the base of the cylinder. The grain entering at the top of the cylinder flows down over aprons which keep it spread and delay the time of reaching the bottom of the cylinder, or the place where it passes out. The grain is only a few minutes in passing through the cylinder, depending on the temperature to which it is heated. Another type of a heater is a revolving horizontal cylinder or drum heated by steam, either passing through pipes in the center of the cylinder or by a steam jacket surrounding the grain cylinder. The revolving cylinder is slanted just enough so that grain entering at one end will soon pass, as it is being agitated, to the other end, where it passes out. A modified type of a drum heater, McDonald and Scholl (1922), is used very extensively in the cotton belt of the United States for the treatment of cotton seed.

B. Fumigation of Grain.

Carbon Disulphide. — While carbon disulphide fumigation is effective and is strongly recommended for all insect infestations in the farmer's bins, it is not an effective fumigation in flour mills; and since there is such an element of danger from fire in its use in these mills and in large grain elevators, it is not recommended for this purpose. It is prohibited by mill and grain-elevator insurance companies, and the use of it voids the policies.

The Amount of Carbon Disulphide to be Used. — The amount of liquid to be used depends on the temperature and the size and tightness of the building. Since temperature is a very important factor in the success of fumigations, it should always be given careful consideration. If the building is reasonably tight and the temperature is obout 70° F, one pound of carbon disulphide is sufficient for every 25 bushels of grain. In empty bins, or space not filled with grain, five pounds of carbon disulphide is sufficient for every 1,000 cubic feet of space. In case the building or bins are not sufficiently tight to allow thorough fumigation, the amount of the liquid should be doubled or even tripled. At a temperature below 60° F, the amount of carbon disulphide required and the results obtained are so unsatisfactory that it is impracticable to attempt fumigation.

Preparation. — The building and bins must be as nearly airtight as possible in order that the vapor may remain in all parts of the space in full strength and for the required time. Doors should be wedged tight. If they are loose, either paper should be pasted over them or cotton batting should be inserted in the openings with a case knife. A similar treatment should be given all holes and cracks in the wall and floor. The batting should be packed tightly. Care should be taken to have everything ready and in place, so that after the distribution of the liquid has begun, it will be unnecessary to stop to adjust anything. Everything should be done to avoid unnecessary delays and to facilitate the rapid evaporation of the liquid.

Placing the Liquid. — Since the vapor is heavier than air and settles to the lower parts, the liquid should be placed in shallow pans at the top

of the grain or poured on burlap sacks partially buried in the top of the grain. It should be well distributed and if large amounts are used in one place, considerable evaporating surface should be allowed.

Length of Exposure. — The bins or building should be allowed to fumigate 36 hours. If the grain is not to be used for germinating purposes, it is well to subject it to the fumigation for 48 hours. The best plan usually is to apply the liquid on a Saturday afternoon and leave the building closed until the following Monday.

Ventilation. — Doors and windows should be opened wide and the building or bins aired thoroughly one or two hours before being entered. Slight traces of the odor will linger in corners and other places where the air does not circulate freely, but these will gradually disappear.

Precaution. — The vapor of this liquid is highly inflammable and explosive. No fire or light of any sort should be allowed about the building while the fumigation is in progress. The application should always be made in daylight, for artificial light of any kind in dangerous. Electric lights must not be used, since when turning them on or off there is always danger of producing a spark. It is not safe to have heat of any kind in the building while the fumigation is in progress.

Ethyl Acetate-Carbon Tetrachloride Mixture. — Due to the danger of fire and explosion by the use of carbon disulphide, an investigation was conducted by the United States Department of Agriculture to find a substitute. A mixture of ethyl acetate and carbon tetrachloride was tested and recommended by Neifert et al. (1925) during the latter part of 1924, as a fumigant of grain in cars. However, the ethyl acetate-carbon tetrachloride mixture has not become established in the grain trade, due probably as suggested by Back and Cotton (1926) who state "Since the ethyl acetate-carbon tetrachloride mixture is no more effective than carbon disulfide, leaves an odor on the grain, and in some respects is not quite so satisfactory from a toxicity standpoint under all conditions, it remains for the individual to determine whether its greater cost affects the advantages of freedom from fire hazard."

Carbon Tetrachloride. — Carbon tetrachloride has been given a thorough trial in the grain trade and is still used to some extent. The danger of fire hazard is removed, since this fumigant is non-inflammable and non-explosive. However, these advantages are greatly offset by its poor toxicity.

Carbon Tetrachloride, Carbon Disulphide and Sulphur Dioxide Mixture. — The demand and need of a good substitute for carbon disulphide led several commercial companies into the field. Several mixtures of carbon tetrachloride and carbon disulphide were tested in attempting to eliminate the danger of fire and explosion and at the same time retain the toxic properties of carbon disulphide. These mixtures have not received the complete sanction of the railway and insurance companies, due to the tendency of the gases to separate.

At this writing, a commercial product consisting of a mixture of carbon tetrachloride, carbon disulphide and sulphur dioxide has shown promise in the laboratory tests conducted at the Kansas Agricultural Experiment Station. While conflicting reports have been received from the

grain trade, most of the commercial reports regarding this material have been favorable. Should this material be stabilized to meet the approval of the insurance underwriters, further tests will be conducted to determine its efficiency and the proper dosages under commercial conditions.

Cyanogas "G" Fumigant. — Although hydrocyanic acid gas (HCN) has been a standard mill fumigant for many years, it was not until 1926 that it was successfully used as a stored grain fumigant. During the years of 1923 and 1924, an attempt was made to use Liquid HCN for the fumigation of stored grains. The use of this material was found to be impractical, due to uneven diffusion and lack of penetration. Another cyanide product, Schenk (1926), was developed during the years of 1925—26. — This product, which is known to the trade as "Cyanogas 'G' Fumigant", is a crude granular calcium cyanide that evolves hydrocyanic acid gas upon exposure to atmospheric moisture. Since Cyanogas "G" Fumigant is fed directly into the grain stream, the necessity of penetration and diffusion is eliminated.

Commercial tests run on wheat with a moisture content as low as 11% and laboratory tests of a moisture content of 10.2% showed that there was sufficient moisture available in the wheat to replenish the moisture removed from the interstitial places surrounding the kernels of wheat and particles of cyanide, thereby insuring complete evolution of the gas in a dense mass of grain.

Separation of the fumigant particles and the wheat after entering the bin was tested. In one bin of sixteen feet diameter, the wheat and Cyanogas "G" Fumigant stream was conveyed directly to the center of the bin and then directed straight downward. Another similar bin without the spout, was used as a check. Repeated experiments showed no differences in kill.

Should the occasion arise that separation should occur in the old type of bins of 30 to 40 feet diameter, the stream could be controlled in a similar manner to the center of the bin and then directed downward. This latter procedure causes a cone of wheat to form in the center, thereby insuring good distribution.

Apparatus for Applying Cyanogas "G" Fumigant. — At the start of the experiments, it was thought advisable to spread an even stream of cyanide the full width of the grain stream. A roller feed hopper was devised to feed a stream of cyanide 18 inches in width or the width of the stream of grain. The rusting of the iron roller used in this hopper was found seriously to interfere with the rate of flow. A new hopper with a wooden roller was then devised. This machine fed a stream of cyanide only 12 inches in width.

A gravity feed applicator was later developed, as shown in text-fig. 1. Tests made with the new applicator showed that distribution of the material was obtained without spreading the cyanide over the stream of grain before entering the bin. Care in using the gravity feed applicator must be taken, however, that the stream of Cyanogas "G" Fumigant is directly on the grain stream upon or before entering the bin. Should the Cyanogas stream be directed into the bin separately from the grain stream, an uneven mixture might result.

Fig. 1 — Gravity Feed Applicator with a drum of Cyanogas in the feeding position. (After the American Cyanamid Co.)

Still later the manufacturers determined the rate of flow of Cyanogas "G" Fumigant through the various sized orifices needed for grain fumigation. The rates of flow are as follows:

Pounds per hour	Bushels per hour	Size orifice inches	Size Drill
8	320	—	—
12 1/2	500	—	—
20	800	.210	No. 4
25	1000	.228	" I
50	2000	.302	" N
75	3000	.343	11/32 in.
100	4000	.390	25/64 "
125	5000	.453	29/64 "
150	6000	.484	31/64 "
200	8000	.500	1/2 "
250	10000	.531	17/32 "

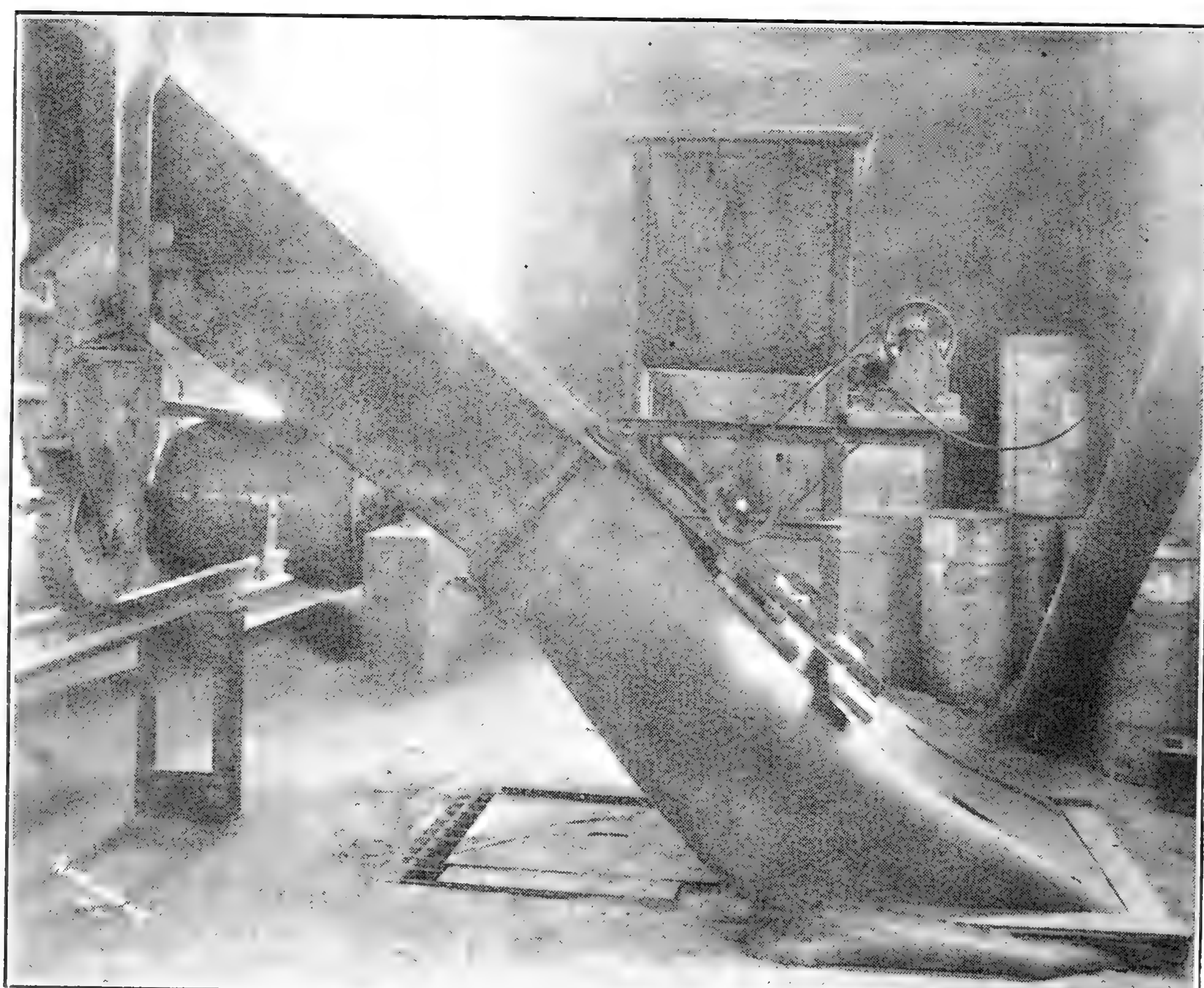


Fig. 2. — Canvas Cover around Stream of Wheat. (After American Cyanamid Co.)

It is now possible for the elevator superintendent to devise a hopper to fit local conditions and regulate the flow of Cyanogas "G" Fumigant by simply drilling the correct size orifice in the hopper.

Amount of Material to be used. — Cyanogas "G" Fumigant should be applied at the rate of 25 pounds for each 1000 bushels of wheat. The evolution of the gas does not depend upon outside temperatures; therefore, wheat may be effectively treated whenever the insects infesting the grain are active.

Length of Exposure. — The grain should be allowed to stand for a 72 hour period. No special moving of the grain is required at the end of this period.

Circulation of Air above the Bin. — The operator should always stand on the windward side when filling the hopper, making observations or oiling the tripper or nearby machinery and should not remain close by longer than necessary.

Good ventilation is essential to allow the displaced air, which carries some evolved gas, to escape to the outside.

Where special fumigation bins are desired, the ordinary type of closed top bin can be fitted with an outside vent and the stream of grain from the tripper spout to the bin can be enclosed with a canvas bag, as shown in text-fig. 2. The displaced air will then be carried outside of the "texas".

Sweeping out after Fumigation. — At least fifteen minutes should be allowed for airing after emptying the average type of bin, where the operator enters from below. In bins over forty feet in height and where the operator entering to sweep out the bin must do so from the top, several hours should be allowed. Where possible in this type of bin, the bottom slide should be left open and twenty-five to fifty bushels of wheat run through the bin, thereby eliminating the necessity of sweeping the bin.

These precautions apply only to freshly treated grain. Bins of long standing or once moved can be handled in an ordinary manner.

Effect upon Milling, Baking and Feeding Qualities. — Swanson and Working (1926), of the Department of Milling Industry, Kansas State Agricultural College, made further tests and found no injury resulted from this treatment and that the effect of treating wheat with Cyanogas "G" Fumigant in no way differed from that brought about by fumigation with other HCN products.

Yellow Spotting on White Corn and Polished Rice. — Yellow spotting occurs when grains having white surfaces are treated with Cyanogas "G" Fumigant. This fumigant is not recommended for the treatment of these grains. Several firms have reported using Cyanogas "G" Fumigant on white corn where the corn is not to be placed on the market as such, but which is to be ground into feed and meal.

PART II. CONTROL OF FLOUR MILL INSECTS.

A. Preventive Methods.

In Flour Mills and Warehouses. — The principal sources of insect infestation in the flour mill are:

1. Storing and reconditioning in the mill returned infested flour and other milled products.

2. Using second-hand sacks that have been returned from bakeries and blending plants.

3. Milling wheat that is infested as it comes from elevator to the cleaning room.

4. Permitting the accumulations of old products in and about the plant.

Since so much of the insect infestation in flour mills and warehouses is directly traceable to a disregard to cleanliness and the accumulations of old products, it is very important to keep the entire plant scrupulously clean by sweeping up all accumulations of flour, meal and bran on the floors, in the corners, under machinery and in all places where it may find lodgment. These materials, together with bags of old products, should be removed from the mill and disposed of in such a manner as not to be brought back into the mill.

About every four weeks during the warmer months, all accumulations of flour and meal in the elevator boots, flour conveyors, sifters and purifiers should be cleaned out and removed from the mill. Before removing these accumulations, it is well to go over the elevator legs and spouts with a rubber mallet or spout maul to jar loose the insects and infested accumulations.

In flour warehouses, the floors should be thoroughly swept and all accumulations removed after each movement of flour.

All walls and ceilings of the mill or the warehouse should be smooth, so as not to afford hiding and breeding places for insects.

In order that infestation be avoided in the dark corners and other places in the basement, a liberal amount of air-slacked or hydrated lime should be used. This lime not only will act as a repellent for the insects, but it will also tend to destroy some of the objectionable odors and sweeten the air in damp basements.

Building should be constructed so as to avoid damp, dark places. Floors and walls should be joined so that accumulations along the edges and in the corners can be easily swept out. Floors of all basements should be cemented and all walls should be smooth.

All machinery should be placed so as to allow thorough cleaning and brushing around and beneath it. As far as practical, the bottoms of all flour conveyors should be metal, and rounded in such a manner as to allow the least amount of flour or meal to accumulate in inaccessible places.

Sacks or bags should not be stored in packing rooms or in any part of the mill where flour or meal may collect on them and thus afford breeding places for insects. The sack room should be a separate room or tightly partitioned off from any part of the mill.

Since the handling or using of second-hand sacks affords one of the best possible means of infesting a flour mill with several of the most serious mill pests, the sacks should be heated or fumigated in an isolated room or outside building before they are brought into the mill, or the practice of using second-hand sacks should be stopped at once. A well equipped and modern constructed fumigatorium is an essential part of a flour mill.

The grain cleaning rooms of the mill should be located and constructed so as to avoid as far as possible the infestation of the mill and the ware-

house by the insects which have been removed from the grain in the cleaning process. The bags of cleanings should be removed from the cleaning room before the insects crawl from them to infest part of the mill, or treated with a fumigant as the container is being filled.

B. Heat as a Means of Control.

While heat has been recognized for many years as a control measure for insects infesting small amounts of stored grain, its effectiveness as a control measure for the control of all insects infesting a flour mill was first developed by experimental investigations conducted by Dean (1913), of the Kansas Agricultural Experiment Station, in the laboratory and in several Kansas flour mills during the period of 1910—1913. Following the experimental work, practical demonstrations were conducted in several flour mills representing different types of buildings or of construction. So successful were the demonstrations that the heat method was thoroughly tested by the Bureau of Entomology, United States Department of Agriculture (Back 1920) and by entomologists in several States (Goodwin 1922), with the result that flour mills in Kansas, Missouri, Ohio, Nebraska, Oklahoma, Illinois, Indiana, Virginia, Iowa, Southern Canada and elsewhere were equipped for using the heat method. The result of these tests have been so successful that today the heat method is recognized as one of the most effective, practical, convenient and inexpensive of all mill treatments, and has the added advantage of being absolutely safe.

Degree of Heat necessary. — A temperature of from 120° F to 125° F in all parts of the mill for a period of from 10 to 12 hours is sufficient to destroy all insect life. To obtain these killing temperatures in the parts least exposed to the radiation, the air should be kept in circulation by means of fans or by running the machinery. The fans should be located so as to keep the hot air moving away from the radiators. If this is not done, some parts of the mill naturally will reach a higher temperature than necessary. Steam heat at a pressure of from 25 to 40 pounds in well distributed steam pipes is the most satisfactory method for securing fatal mill temperatures.

Most Effective Time to heat. — In order to take advantage of the normally high temperatures, it is advisable to apply the heat during the summer months. With summer temperatures of 85° F, or above, it takes less fuel, less radiation surfaces and less time. It is difficult and in some buildings almost impossible to get uniformly good results during windy weather. In frame buildings covered with sheet iron, it is not possible to get good results if it is raining, particularly if it is a light rain lasting for several hours.

Amount of Radiation required. — The number of square feet of radiation surface required to heat a given number of cubic feet depends upon the construction and condition of the building, the number of windows and doors on each floor, the character of the machinery, and the location of the steam pipes. Since these factors vary so greatly in flour mills, definite recommendations for the amount of radiation cannot be given. The engineer of each plant after one or two experimental heatings, will be able to increase or reduce the amount of radiation surface in various

parts of the mill so as to secure sufficient high temperatures. Usually one square foot of radiation is sufficient to heat from 50 to 100 cubic feet of space. A mill that has sufficient radiation to heat it in winter to a temperature of 70° F without the friction heat of the running machinery will require only a small amount of additional radiation, if any, to heat it in summer to a temperature of from 120° to 125° F.

If the mill is a five story building, the writers would suggest one square foot of radiation to each 50, 60, 75, 100 and 110 cubic feet of space for the first, second, third, fourth and fifth floors, respectively. The amount of radiation surface per linear foot, and the linear feet of pipe required to make one square foot of radiation surface for pipes of various sizes are as follows:

Size of pipe in inches	Radiating surface per linear foot	Linear feet of pipe per sq. ft. of radiating surface.
1	0.346	2.9
1 1/4	0.434	2.3
1 1/2	0.494	2.0
2	0.622	1.6
2 1/2	0.753	1.3

If steam pipe is used for the radiation, either 1¼ inch or 1½ inch pipe is recommended as most practical.

Important Points to be considered in the successful Heating of a Flour Mill.

1. The steam pipes should be located near the floor and so arranged as to give an equal distribution of heat.

2. There should be water traps to draw off all water accumulating in the pipes and radiators.

3. The lower floors and the floors with heavy machinery should have more radiating surface in proportion to the cubic feet of space to be heated than the upper floors and the floors with light machinery.

4. The steam should be turned on with from twenty-five to forty pounds pressure, so as to heat the mill more rapidly.

5. Since insects die more quickly in a dry heat than in a moist heat, do not allow the escaping of any steam in any part of the mill.

6. In order that advantage may be taken of the heat in the machinery, the heat should be turned on immediately after the mill is shut down.

7. Stairways and elevator shafts should be closed, so as to make each floor a separate unit.

8. Thermometers should be placed at different points on each floor in order that the temperatures may be readily ascertained.

9. Time must be taken to reach the desired temperature.

10. A temperature of from 120° to 125° F is sufficient for any part of the mill.

11. Fans should be provided on each floor near the radiators to keep the air in circulation, or the air should be kept in circulation by running the machinery at regular intervals.

12. This temperature should be maintained for several hours to allow the heat to penetrate all the infested parts.

13. Do not allow some parts of the mill to heat up to 150° F or more.

14. If the machinery is not to be run for circulation, loosen all belt tighteners, but there is no need of removing the belts.

15. Do not attempt to heat a mill on a windy, cold, or rainy day.

16. By beginning the heat process directly after shutting down the mill Saturday evening and continuing until Sunday midnight, the mill should be ready to run Monday morning.

Flour not affected by the Heat Method. — In connection with heat fumigation, the question naturally arises as to whether the heat would have any deleterious effect upon the baking quality of the flour. To obtain data upon this subject, baking tests were made of a patent hard-wheat flour, a low grade hard-wheat flour and a pancake flour. These flours were subjected to a heat several degrees higher than that recommended for a mill. Not only was the low grade hard-wheat flour subjected to a temperature of 140° F for nine hours, but the same samples were subjected to the same temperature two and six weeks later to ascertain whether a second and a third heating of the same flour would have any injurious effect. The pancake flour was subjected to a temperature of 130° F for forty-eight hours. The baking tests of all these experiments showed conclusively that the heat had absolutely no deleterious effect upon the baking qualities of the flours.

Mill Equipment not injured by the Heat. — Heating flour mills as recommended for the control of mill infesting insects will not injure the mill structure or equipment. In practically all instances where injury to the equipment has been reported, the temperatures around the injured equipment was considerable above 150° F and the excessive temperatures were maintained much longer than the temperatures which are recommended for the mill. In a few instances where there has been excessive moisture condition in the basement, there has been some warping and drawing apart of the elevator boots or legs.

Data have been taken not only on the heating of many mills, but several milling companies have also been using heat for many years and no injury has occurred to belting or machinery, or by checking or warping of the woodwork of elevator legs, spouts, bolters, sifters and purifiers. Since the heat will soften and cause tight belts to stretch, it is advisable to loosen all belt tighteners, but there is no need of removing the belts.

Objection made that insurance companies will not permit the heat method of control, especially where the mill is equipped with the automatic sprinkling system, is without foundation. Several years ago, Mr. William Reed, who was secretary of the Mutual Fire Protection Bureau, representing eight of the principal millers' insurance companies, in a notice to all policy holders, stated: "We propose to advocate the heating system for effective fumigation against Mediterranean flour moth, weevil, and all other mill and grain infesting insects."

C. Combination of the Heat Method and Liquid Hydrocyanic Acid Gas or Chlorpicrin.

Where difficulties are encountered in obtaining sufficient high temperatures in the basement or on the roll floor or in the packing room of the mill, it is suggested that these floors be piped for fumigation with liquid HCN and after the mill has been heated long enough to get temperatures of from 110°—115° F in these places, to fumigate with the liquid HCN. The warm, dry temperatures will not only cause the insects to become more active and run out in the open, but it will also give a heavy concentration of gas almost at once, which should cause the death of the insects in less than a minute. Chlorpicrin could also be used in this manner. It would not be practical to use the calcium cyanide products in this manner, since the humidity in the rooms would be too low to evolve the HCN.

Hydrocyanic Acid Gas Fumigation.

The problem of flour mill fumigation with hydrocyanic acid gas is separate and distinct from other enclosed space fumigations with this fumigant.

Enclosed space recommendations usually state that each floor of a building should be sealed and fumigated as a unit. This would necessitate the plugging or stuffing of all belt openings, spouts and openings in machinery leading from floor to floor.

Inspections and observations after fumigations have shown live insects in spouts and other openings that have been plugged with sacks during the cleaning before fumigation. Frequently in removing accumulations of infested mill products from machinery before fumigation, it is advisable to plug a spout just below a hand opening and brush or blow the material down the spout to the opening where it can be more easily removed. Invariably where this sack has not been removed before fumigation, insects will be able to survive the fumigation in these places. Therefore, it has become a practice of mill fumigators to consider the building as a unit, and to treat the lower floors with heavier dosages, thereby making allowances for the natural tendency of the gas to rise.

The problem of export flour arriving at destination in an infested condition has changed the purposes of mill fumigation with hydrocyanic acid gas. In past years, only the control of the Mediterranean flour moth was expected, the confused flour beetles and other mill insects were found to survive the fumigations in large numbers. Since it has become necessary to control all flour mill insects, several changes have been made to meet the new problems. The cleanup and preparation of the mill for fumigation became more detailed and of greater importance. The amounts of hydrocyanic acid gas used per thousand cubic feet were increased and the exposures were lengthened.

The problem of hydrocyanic acid gas fumigation became a problem of penetration and diffusion into cracks, crevices, and dead air spaces. Not only must the gas reach these places, but it must do so in lethal concentrations.

Preparation of the Mill for Heating and Fumigation.

Sealing the Mill. — The effectiveness of fumigation depends largely upon the tightness of the building. All windows should be tightly wedged or sealed; all broken panes should be replaced or sealed. Loose fitting window frames should be sealed with paste and paper, or "puttied up". All cracks leading outside the building should be sealed with heavy paper. All doors should be well sealed; sliding or jointed doors that are difficult to seal with paste and paper may be sealed by filling the cracks with wet paper or a heavy grease.

Special care should be taken to make certain all ventilators are well sealed, three thicknesses of heavy paper covered with sacking or canvas well pasted and tied will be sufficient when sealed from the roof. Some ventilators are more easily sealed from the trap box below the ventilator.

Cleaning the Mill.

Before Stopping Mill:

1. Shut off feed (wheat) at mixing bin.
2. Continue running all machinery until material is emptied from spouts, elevators, conveyors, rolls, sifters, reels, purifiers, feed duster, suction trunking and dust collectors.
3. Meanwhile, hammer elevator legs, machinery, frames, tubular dust collectors and spouts with a rubber mallet or other device which will not bruise or injure the equipment.

After Stopping Mill:

1. Open all machines, elevator boots, conveyor boxes and flour bins.
2. Remove covers of all conveyors, making certain that all dead end spaces are readily accessible.
3. Thoroughly clean all conveyors, including dead end spaces.
4. Clean out accumulations from bottom section of the bran duster.
5. Clean all elevator belting that may be webbed; drag spouts of same.
6. Remove the adjustable feed gauge above grinding rolls and clean out accumulations above rolls and feeders.
7. Examine tubular dust collectors and clean out all accumulations.
8. Clean out suction trunks, conveyors and dust collector systems.
9. Open dust collector trap boxes, main trunks, and hand openings.
10. Loosen all sifter doors to permit entrance of the gas during fumigation.
11. Leave every machine open; also all hand openings to spouts, elevator legs, etc.
12. Remove and burn all infested materials accumulated in cleaning the mill.
13. All infested lots of flour and other milled products should be removed (or reconditioned) before cleaning the mill. These products should not be returned.
14. If the above procedure is followed, no accumulation of more than one inch in depth will be present in the mill.

15. Special attention should be given to the cleaning of the "dead" spouts and "dead" spaces in corners of spouts and machines.
16. Remove all bags or other materials used to plug spouts.

Sodium Cyanide or Pot Method: 54% HCN. — The "Pot Method", because of the cumbersomeness of the method of application, the dislike of the millers because of broken jars and the rapid escape of the heated gas from the building, is little used. At the end of a short period, three to four hours, the lethal concentration required for flour beetles rarely remains in the building.

Formula. McDonnell (1911): Three pounds of sodium cyanide, four pints sulfuric acid, six pints of water.

The formula which is more frequently used in the flour mills of the United States is as follows:

1 ounce, by weight, of sodium cyanide,
1½ ounces, liquid measure, of sulfuric acid,
2 ounces, liquid measure, of water.

This is known as the 1—1½—2 formula.

Amount of Sodium Cyanide for each Floor. If the building is well constructed and reasonably tight, the following standard may be followed:

Basement, one pound to every 800 cubic feet of space, unless elevator boots extend to basement, in which case use one pound to every 600 cubic feat of space.

First floor, one pound to every 800 cubic feet of space;
Second floor, one pound to each 1,000 cubic feet of space;
Third floor, one pound to each 1,200 cubic feet of space;
Fourth floor, one pound for each 1,300 cubic feet of space;
Fifth floor, one pound for each 1,400 cubic feet of space.

Where the majority of elevator boots do not extend to the basement, the extra materials should be added to the floor having these openings.

In most mills this procedure will average approximately one pound of sodium cyanide for each 1,000 cubic feet of space.

Liquid HCN: 96—98% HCN. — Figures obtained during 1927 from a commercial fumigation company using this product for mill fumigation were five ounces of Liquid HCN for each thousand cubic feet of space for the control of the Mediterranean flour moth. In fumigating the Kansas State Agricultural College experimental mill, this firm used 99 pounds of Liquid HCN for about 200,000 cubic feet of space, or eight ounces for each 1,000 cubic feet of space. This was considered the dosage required for the control of all flour mill insects. Under favorable conditions, this fumigant will hold a lethal concentration required for flour beetles for a period of about six hours.

Amount of Material to be Used. — Eight ounces of Liquid HCN for each 1,000 cubic feet of space should be used. It is preferable that this amount be applied as follows:

At start — 4 oz. to 1,000 cubic feet of space.
Two hours later — 2 oz. to 1,000 cubic feet of space.
Two hours later — 2 oz. to 1,000 cubic feet of space.

This method of intermittent application, which is recommended by the manufacturers for the control of *Lasioderma serricorne* Fabr., tends to

hold a lethal concentration for a longer time, the original release of four ounces is ample for exposed insects.

Application. — Liquid HCN is applied from the outside of the building through a system of 3/8 inch iron pipes. Pressures are maintained to raise the liquid through the risers to the pipes on each floor of the building and to atomize the liquid as it leaves the spray nozzles.

Piping System to insure good Distribution. — The piping system should be designed to insure distribution of the gas to all parts of the building. These plans are usually designed by an employee of the fumigation company from an actual survey of the building.

Should blueprints of the mill or rough sketches and measurements be forwarded for making piping plans, special attention should be given to offsets and whole or parts partitions.

Any other special conditions, such as heavily infested machinery, rows of packing machines, or other places of heavy infestation should be noted in order that an extra spray nozzle may be added at this point if thought advisable by the expert making the drawings. There should be at least one spray nozzle for each 800 square feet of floor space and not more than 10 spray nozzles to each riser. Where grain or flour bins are piped, a separate riser for these bins should always be used.

Removal of Spray Nozzles after Fumigation.—The spray nozzles should be removed after each fumigation and the pipe openings capped. It is advisable to wash each nozzle with kerosene or similar product before storing for next fumigation.

The operator should exercise every precaution while removing spray nozzles to prevent any liquid that sometimes remains in the pipe from dripping onto the face or other parts of the body. One should never stand under the nozzle while removing the nozzle. Should Liquid HCN be lodged behind the nozzle, a decided cooling effect will be noticed while unscrewing the nozzle.

Dosage and Procedure used in Demonstration. — The dosage, procedure, and precautions recommended were followed by the representative of the manufacturers, with the exception of the intermittent application, while demonstrating their product at the Kansas State Agricultural College experimental mill for the control of all flour mill insects.

Liquid HCN should only be applied by an experienced operator.

Calcyanide: 51—52% HCN. — Calcyanide is a commercially pure calcium cyanide, 88% $Ca(CN)_2$, that evolves HCN on exposure to atmospheric moisture. It is very finely divided and brown in color. This material gives off HCN very rapidly, the peak of the concentration being reached at the end of about one-half hour. Therefore, in terms of holding a lethal concentration, this fumigant will come in the six hour period.

Amount of Material for Each Flor. — Same as under sodium cyanide.

Application.—The material is shipped in cans of convenient size, having a perforated lid. The friction lid below the perforated lid is removed and the perforated lid replaced after the material has been distributed about the building in the proper places. The operator or operators now proceed to the top floor farthest from the exit. Calcyanide is shaken onto strips of paper while working towards the exit to the floor below. Care should

be exercised to deposit a layer about one-sixteenth inch in depth. Each succeeding floor is treated in a similar manner.

Where the exit to the outside is on the first floor, the basement should be treated before the first floor. Since the HCN is rapidly evolved, a gas mask should be used.

Disposal of Residual Material.—After fumigation, the papers on which the fumigant has been spread are rolled up, carried out of the building and burned.

Calcyanide should only be applied by an experienced operator.

Cyanogas "G" Fumigant: 23—29% HCN. — (Bromley 1928) Cyanogas "G" Fumigant is a crude calcium cyanide (40—50% $Ca(CN)_2$) that evolves HCN on exposure to the surrounding air. Cyanogas "G" Fumigant evolves HCN slowly, four to six hours being required for complete evolution under favorable mill fumigation conditions. This slow evolution of HCN is advantageous in holding a lethal concentration over a long period. However, under certain conditions the rate of evolution of HCN from Cyanogas may become too slow. Since the rate of evolution of HCN from calcium cyanide depends upon the size of the particle, thickness of the layer, and the amount of moisture present in the air, it is possible that under an unfavorable set of conditions, and where undue leakage occurs, a killing concentration for flour beetles may never be reached, as the evolved gas might escape practically as rapidly as it is being liberated; therefore recommendations must be followed carefully.

Amount of Material to be used. — Since the HCN content of Cyanogas "G" Fumigant is about one-half as great as sodium cyanide, double the amount should be used. The distribution of this amount per floor is the same as given under sodium cyanide.

Application. — The material is shipped in convenient sized containers, or can be purchased in one hundred pound drums. The proper portions are distributed about the building near the exit of each floor. Should the material be poured from the one hundred pound drums into small containers, these containers should be well closed or covered with paper and a burlap bag. The operator or operators now proceed to the top floor farthest from the exit, and by means of two men working together, one pouring from the container to a shovel, the other broadcasting the material thinly and evenly over the floor, or each operator using a bucket and a small hand scoop to spread the material, while working towards the exit to the floor below. Each floor should be treated in a similar manner. Where the exit to the outside is on the first floor, the basement should be treated before the first floor.

Disposal of Residual Material. — The residual material being heavy and granular can be swept up, after proper airing, and disposed of on a nearby dump.

Safe Fumigation of small Mills by the Layman. — Cyanogas "G" Fumigant, due to the slow evolution of hydrocyanic acid gas, has been considered a safe hydrocyanic acid gas fumigant for the layman. However, the use of the large amounts required for mill purposes is a new departure from the use of Cyanogas in small quantities for rodent control or house fumigation (Smith 1926).

In addition to the larger amounts required for mill fumigation, special measures are taken to hasten the evolution of the gas; therefore, the use of Cyanogas for mill fumigation purposes, where over 400 pounds of material are used, should be done only by experienced operators.

Where small mills are to be fumigated, using 400 pounds of material, or less, there is little risk, providing detailed directions given out by the manufacturers are followed. There should never be less than two men on a job of this sort, preferably four men, to apply the material and one man in charge of operations.

The man in charge of operations should carry a gas mask, *but not wear it*, unless necessary.

Liquid HCN and Cyanogas "G" Fumigant. — During 1927, the practice of using a combination of Liquid HCN and Cyanogas "G" Fumigant was started in the South-western Milling District of the United States and later adopted in the North-western District. The Liquid HCN is used to raise the concentration at the start and the Cyanogas "G" Fumigant is used to evolve HCN over a long period, thereby tending to hold the concentration of liquid originally released. This method will hold a lethal concentration longer than liquid alone and has consistently given better results in Missouri, Kansas, and Oklahoma than either material used alone.

No definite proportions have been worked out. When first started in 1927, about 75% of liquid and 25% Cyanogas "G" Fumigant were used. An ideal combination would be one pound of Cyanogas "G" Fumigant and four ounces of Liquid HCN for each 1,000 cubic feet of space.

Zyklon B: 33—40% HCN. — Zyklon B is a mixture of liquefied hydrocyanic acid gas and chlorpicrin absorbed in Fuller's earth. HCN is released by vaporization. This material gives off HCN very rapidly and, since the product is absorbed HCN, results similar to Liquid HCN are to be expected for industrial building fumigation, as well as ship, vault, and city fumigation. The chlorpicrin is a warning gas which, by its irritating effect upon the membranes of the eyes and throat, warns any person entering the mill that the mill has not aired sufficiently. An attempt to demonstrate this material as a mill fumigant in the United States during the summer of 1928 brought out difficulties in the method of application under American conditions which must be corrected before the material can be safely used for this purpose. However, Zyklon B is now used in the country for ship, vault, and city fumigation purposes and a better method of application for mill fumigation is being developed by the manufacturers.

Length of Exposure for HCN Fumigation.

Under the most favorable conditions for mill fumigation, it is impractical to hold a lethal concentration necessary to kill flour beetles for longer than a twelve-hour period. Therefore, an eigtheen-hour exposure should be sufficient to secure the best results obtainable with the present methods of fumigation. The added six-hour period is advantageous in that, although the concentration may be low at the end of a twelve-hour period, many insects secreted in places difficult to reach may be only stupefied at that

time and the continued exposure even to a low concentration may be sufficient to prevent revival of these insects.

This length of exposure also allows for a mill to be fumigated and aired within a twenty-four-hour period, an important factor where production is essential.

Ventilation for HCN Fumigation.

Where Gas Mask is Used. — Open all main doors and windows on first floor, proceed upward, opening all windows on each succeeding floor until reaching the top. Then descend to basement and open all windows and doors.

Where no Gas Mask is Used. — Two windows on each floor should be arranged to open from outside the building by means of a rope or stout cord. These windows and all doors, previously arranged to open from the outside, should be opened wide. The building should be allowed to air for one or two hours before entering to open more windows. Doors and windows on the side opposite to the direction of the wind should be opened first. At the end of another period of one or two hours, the operator should enter to open more windows. All corners and parts of the building should be visited before allowing the workmen to enter.

Special Precautions Required. — The average basement is usually damp and poorly ventilated. Since HCN is absorbed by moisture, special attention should be given to see that basements are properly aired before the building is entered by workmen.

In poorly ventilated rooms where quantities of milled products or bags are stored, care should be exercised in opening the building the following morning, since considerable quantities of HCN are absorbed by these products. Wherever possible, it is best to allow a window to remain partly open the first night following fumigation.

The Efficiency of HCN Fumigation.

HCN is not expected to penetrate deeply into wheat or milled products under ordinary enclosed space conditions; therefore, unless the mill is thoroughly cleaned, poor results will be obtained.

The Frequency of HCN Fumigation.

The increased dosage used for the control of all flour mill insects, instead of the lighter dosage formerly used for the control of the Mediterranean flour moth, has given good results. However, there is still a question whether the HCN penetrates to all parts of the milling machinery, even under the present recommended conditions. Investigational work is being done to determine definitely what control of flour beetles is secured by HCN fumigation.

A yearly fumigation is now practiced by millers using HCN. This practice usually proves satisfactory for the control of the Mediterranean flour moth. However, the inspections made by the Illinois, Missouri, Kansas, Oklahoma and Texas State Entomologists for the certification of mills exporting flour, indicate two yearly fumigations will be necessary for the control of all mill-infesting insects.

To what extent the reinfestation of the mill, within several months after fumigation, is due to the insects not killed by HCN fumigation or reinfestation from outside sources remains to be determined.

Before frequent fumigation to control flour beetles becomes unnecessary, the chief sources of infestation, such as infested wheat, returned goods, and returned bags, will need be checked. Then the yearly fumigation probably will control all mill insects.

Chlorpicrin as a Mill Fumigant.

Since chlorpicrin is highly toxic to insects and is non-inflammable and non-explosive under ordinary conditions, its use as a mill fumigant has been tested. Chapman and Johnson (1925) found that "When chlorpicrin is present in the flour, deleterious effects are noted in the bread produced from such flour", but that "Fumigated flours given proper exposure to the atmosphere show complete recovery from the chlorpicrin treatment."

Strand (1926) states "Chlorpicrin when vaporized within the milling equipment of flour and cereal mills is a very effective fumigant for controlling the Mediterranean flour moth. It is less effective against the confused flour beetle, but several periodic fumigations with chlorpicrin have resulted in a very excellent control of this insect in a mill formerly heavily infested."

Strand further states "Finally, the effectiveness of chlorpicrin for controlling small localized infestations which could shortly be the cause of more widespread trouble, gives it exceptional value as a mill fumigant."

One executive of a nationally known milling company stated he has repeatedly sent samples of untreated checks and flours treated in their fumigatorium with chlorpicrin to the laboratory for baking tests, and no deleterious effect had been noted. Recently a warehouse, owned by this same company, well filled with flour and feeds, was fumigated with chlorpicrin at the rate of one pint for each 700 cubic feet of space. Inspection after this fumigation showed very poor results and indicated either a rapid escape of the gas, poor diffusion, or both.

One Kansas miller used chlorpicrin during June, 1928, as a general mill fumigant. Eigthy-eight pounds of the fumigant were sprinkled into the elevator legs and other machinery while the machinery was in motion. This amount of chlorpicrin was used to treat 133,584 cubic feet of space. The exposure was about 18 hours. The mill had been previously cleaned and sealed according to general fumigation instructions.

Inspection of this mill, made about five weeks after fumigation, showed that excellent results were obtained.

Although there are conflicting reports on chlorpicrin as a general mill fumigant and its effect on the baking qualities of the flour, its high toxicity and penetrating properties are such that it should be developed to its full possibilities as a mill fumigant.

Supplementary Control Measures.

Airtight Fumigatorium. — The use of second-hand bags has long been known to be a chief source of mill infestation by the common

flour mill insects. Many millers will not use such bags, and no miller should bring infested bags into the mill.

Air cleaning of the bag tends to reduce the danger of infestation, but does not eliminate it. Air cleaning is not 100% effective, for many eggs and even small larvae clinging tightly to the fibres of the sacks will be missed. Also, air cleaning machinery is practically always located in the mill proper and the bales may remain from several hours to a few days in the mill or warehouse before reaching the cleaner. This allows ample time for the flour beetles to leave the bales and should a moth infestation have reached the pupal state, adult moths may emerge and infest the mill.

The use of an airtight fumigatorium is the solution of this vexing problem of the miller, for not only should the second-hand bags be sterilized, but also returned infested products should be sterilized before being taken to the mill for reconditioning.

The fumigatorium should be located in a separate building or directly at an entrance of the mill or warehouse, in order that the infested bags, or returned goods, may be placed directly into the vault and sterilized before entering the main buildings.

With the fumigants and methods now used, it is necessary to separate each bag of flour, carton of package goods, or bale of bags. Shelves or racks may be used. Where the bags of flour are tiered, two by fours should be placed near each end of the bags between each tier, because variable results will be obtained where the bags of flour are stacked directly on top of one another. Bales of bags should be opened and separated into bundles of fifty.

HCN as a Fumigant. — The method of evolving HCN becomes less important when used for a period of twelve hours or more in an airtight vault. Amounts of material spoken of below will refer to the actual amount of hydrocyanic acid gas to be used.

One manufacturer recommends the use of approximately eight ounces of HCN (actual) for fumigatorium of 700 cubic feet capacity manufactured by the same company. Their directions are as follows:

"Control: Packed cereals (packed for shipment to the trade) and returned goods. In the case of goods packed not more than thirty pounds to the case, allow the cases to remain exposed to the gas from cabinet calcyanide for a period of 16 hours. Larger case packings should be exposed to the gas for 24 hours.

"Sacked flour. It is impossible to obtain complete penetration because of the extreme density of the flour. However, exposure to the gas from cabinet calcyanide for eight hours will control all surface infestation, while an exposure of 24 hours will result in a fair degree of penetration.

"Returned or exchanged sacks. Tie the sacks loosely in bundles of about twenty-five each, stacking them in the fumigation cabinet on racks of not more than three bundles deep. Allow them to remain exposed to the gas from cabinet calcyanide for a period of 12 hours."

Penetration experiments were conducted by the junior author during the spring of 1928 on the fumigation of 140 pound jute bags of flour and whole bales of 300 used jute bags bound tightly by four wires.

Temperatures and relative humidities were held fairly constant, the temperature ranging within a few degrees of the usual recommendation of 70° F for insect activity.

It was found that 140 pounds bags of flour could be successfully fumigated in a vault of 480 cubic feet capacity by using one and one-half pounds of HCN for a period of 20 hours. When the vault was only partially filled, the dosage could be reduced.

These experiments indicated that the absorption of the gas by the outer layers of the flour prevented penetration to the center of the flour or bales when small amounts of HCN were used. New experiments were outlined to determine the dosage necessary to penetrate to the center at a temperature of 100° F. Only one experiment was conducted, the results of which showed that both bales and bags were successfully penetrated at a lower dosage.

Strand (1927) has drawn the following conclusion from his study of the absorption of chlorpicrin, carbon disulphide, and carbon tetrachloride by whole grains. "As absorption is closely related to temperature (the lower the temperature the greater the absorption), temperature is an important factor in the fumigation of grain aside from its relation to the toxicity of the fumigant, or the activity of the insects being fumigated".

New experiments will be conducted for the fumigation of cereal package goods, bags of flour, and whole bales of used bags to determine a proper combination of heat and HCN.

Chlorpicrin as a Fumigant. — Chlorpicrin is being used by some millers for vault fumigation purposes and excellent penetration and kills are being secured at the rate of one pint of chlorpicrin for 700 cubic feet of space. Due to the odor of chlorpicrin and the irritating effect of the gas remaining for long periods, this fumigant is not being used for package goods, or other products to be marketed without reconditioning.

Since good penetration is secured and since there is little or no difference in effectiveness between this fumigant and HCN, it is possible that it will become commonly used for the fumigation of returned bags and infested flour. However, some work remains to be done to clear up the question of the effect of chlorpicrin upon the baking qualities of the flour, since Chapman (1921) states "Experiments have shown that it has some detrimental effect upon the baking qualities of the flour." Further research by Chapman and Johnson (1925) shows that the baking qualities of flour are injured when even small quantities of chlorpicrin are present, but the effect disappears upon areation before baking.

Heat used in Fumigatorium. — Heat may be used by installing radiation sufficient to heat the center of the bale or bag of flour up to 120° F. Where flour is heated to sterilize before reconditioning, the temperature should not be allowed to rise above 150°F. When only used bags are to be heated, the temperature may be increased to hasten the penetration of the heat to the center of the bags.

The time required uniformly to heat the bags of flour will depend upon the size of the bags and the number of bags heated. This time will run between 24 and 48 hours.

Used Machinery. — When mills are dismantled and the second-hand machinery shipped to other mills, this machinery should be fumigated

in the car before leaving the mill. Buyers of such machinery should carefully inspect same and fumigate before unloading, if signs of infestation are present. The recommendations given under "Box car fumigation" can be followed.

Infestation from Cleaning Room. — This source of infestation presents quite a problem and is probably the chief source of flour beetle infestation.

The heating unit described under "Heating of Grain" should be installed wherever practical. In addition to this, the grain should be carefully watched during the storage season and any wheat showing signs of heavy infestation or heating due to insect activity should be fumigated at once. All elevator bins should be fumigated, when empty, at least once each year.

D. Protection of Flour in Transit.

Railway Car Fumigation. — During 1927 the use of HCN for empty box car fumigation was developed, since infestation of flour sometimes occurs in transit. Over 100 empty box car fumigation experiments were conducted under the supervision of the senior author to determine the following dosages and exposures. One pound of Liquid HCN, eight pounds of Cyanogas "G" Fumigant, or three pounds of Calcyanide may be used for each car. Zyklon B at the rate of 1½ pounds of actual HCN content probably will give equal results, although no tests have been made with this fumigant. The doors should be tightly closed and the car allowed to stand for at least three hours.

This dosage and exposure will control the ordinary flour beetles. When control of the grain weevils is desired, the car should be allowed to stand for eight hours, or longer.

Some millers are closely examining cars used to ship domestic flour, and any found to be infested are fumigated with one of the above mentioned products.

Ship Fumigation. — The care exercised by the export flour insurance companies and the millers to insure flour arriving overseas free of insect infestation, necessitated the fumigation of ships carrying such flour. Careful inspections are being made at the gulf ports of the United States, and any ships found to be infested are fumigated with hydrocyanic acid gas.

Reconditioning Plants. — Some flour has been found to be infested upon arrival at the ports. Care is exercised at the gulf ports by the steamship companies and other interested concerns to free this flour of infestation before loading.

Where the infestation is mostly on the outside of the bags, the bags of flour are brushed with hand brushes. When the flour is found to be infested, it is run through reconditioning plants established for this purpose. Heating units are installed at these plants to sterilize the flour as it is being reconditioned.

Results of Commercial Fumigations—Kansas City, Mo., 1926.‡

Expt. No.	Exp. Days	Cyanogas Lbs. per 1000 bu.	Room Temp.	Rel. Hum.	Moisture of Wheat	Temp. of Wheat	WEEVIL						BRAN BUGS					
							Dead		Stupefied		Alive		Dead		Stupefied		Alive	
							Above the Wheat	In the Wheat	Above the Wheat	In the Wheat	Above the Wheat	In the Wheat	Above the Wheat	In the Wheat	Above the Wheat	In the Wheat	Above the Wheat	In the Wheat
10	1	20	50°F	45%	12 %	60°F.	—	92	—	1.9	—	4.6	—	—	—	—	—	—
x 11	1	19.5	65	30	13.6	65	88.7	93.6	7.5	6.3	3.7	0	—	—	—	—	—	—
1	1	20.0	50	45	12.0	60	—	92.9	—	1.9	—	4.6	—	—	—	—	—	—
3	1	20.7	42	53	14.5	60	92	90	4	1.6	4	8.3	—	—	—	—	—	—
5	1	21.6	32	50	13.8	58	—	90	—	10	—	0	—	—	—	—	—	—
7	1	22.3	60–62	45	14.0	65	77.5	84.5	12.5	15.5	10	0	—	—	—	—	—	—
14	1	23.2	38	75	13.2	50	100	72.5	0	26.1	0	1.2	—	—	—	—	—	—
8	1	23.3	65	45	14.0	65	90	79	10	21	0	0	—	—	—	—	—	—
37	1	24.2	68	57	12.4	60	66	91.8	34	8.2	0	0	—	—	—	—	—	—
40	1	24.2	65	45	12.4	60	85	90.8	15	9.2	0	0	—	—	—	—	—	—
x 12	1	25.6	44	38	13.2	48	90	41.4	10	47.1	0	11.4	100	99.0	0	1	0	0
6	1	27.1	32–33	52	14.0	56	—	97.1	—	2.9	—	0	—	—	—	—	—	—
18	1	27.7	60	39	11.0	80-90	—	70.2	—	25.6	—	4.1	—	—	—	—	—	—
9	1	30.9	63	47	14.2	65-82	—	88.3	—	10.8	—	0.8	—	—	—	—	—	—
13	1	43.9	38	44	13.0	44	98	98.6	2.0	1.4	0	0	100	83.1	0	16.9	0	0
2	2	17.5	60	40	15.0	66-88	—	100	—	0	—	0	—	—	—	—	—	—
16	2	19.8	48	49	12.8	50	38.0	43.3	42.8	56.6	19.0	0	—	—	—	—	—	—
38	2	23.9	68	57	12.4	60	60.0	86.0	40.0	15.0	0	0	—	—	—	—	—	—
17	2	24.0	48	49	12.8	50	70.7	71.0	29.2	29.0	0	0	—	—	—	—	—	—
15	2	24.1	38	65	13.6	40	—	71.3	—	26.6	—	2	—	—	—	—	—	—
19	2	24.7	60	43	12.0	70	—	64.0	—	36.0	—	0	—	—	—	—	—	—
4	2	26.	36	70	14.0	42	95	84.3	0	2.1	5	14.2	—	—	—	—	—	—
24	3	20.2	57	36	13.8	62	100	91.1	0	8.8	0	0	100	100	0	0	0	0
25	3	21.8	68	46	13.0	50	58.3	90.0	41.6	0	0	10.0	100	100	0	0	0	0
*26	3	23.3	67	62	15.4	—	—	70.8	—	29.1	—	0	—	100	—	0	—	0
39	3	25.	65	39	13.4	54	—	97.5	—	2.5	0	0	—	—	—	—	—	—
27	3	25.4	58	61	12.0	60	80	100	20	0	0	0	100	100	0	0	0	0
32	3	25.5	63	26	12.0	60	100	100	0	0	0	0	100	100	0	0	0	0
35	3	26.2	76	28	12.4	70	95	100	5	0	0	0	100	100	0	0	0	0
28	3	26.9	58	61	12.0	55	—	92.3	—	7.6	—	0	—	100	—	0	—	0
21	4	18.1	68	46	12.8	55-85	100	91.0	0	0.9	0	7.9	100	100	0	0	0	0
20	4	21.3	55	37	11.8	80-110	—	100	—	0	—	0	—	100	—	0	—	0
22	4	21.6	67	45	12.2	65-100	82.7	89.8	17.2	2.5	0	7.6	100	100	0	0	0	0
36	4	25.8	75	30	12.0	70	100	100	0	0	0	0	100	100	0	0	0	0
33	4	27.8	75	34	12.0	65	100	100	0	0	0	0	100	100	0	0	0	0
*29	7	23.5	67	45	16.8	60	—	100	—	0	—	0	—	100	—	0	—	0
(–) 31	7	25.3	60	39	12.4	60	—	100	—	0	—	0	—	100	—	0	—	0
30	7	26.3	67	45	12.0	65	100	100	0	0	0	0	100	100	0	0	0	0
34	7	27.2	74	46	12.4	58	100	100	0	0	0	0	100	100	0	0	0	0

‡ Total number of bushels fumigated, 167,831; individual experiments ranged from 1700 to 10,600 bushels.
* No. 6 and 29 was fumigation of corn instead of wheat.
(–) No. 31—Fumigation in wooden bin instead of concrete bin.
x No. 11 and 12—Fumigation with Cyanogas "A" Dust instead of "G" Grade.

Literature.

Back, E. A. — 1920. Insect Control in Flour Mills; in U. S. Dept. of Agr. Bul 872, pp. 27—29.

Back, E. A., and Cotton, R. T. — 1926. Control of Insect Pests in Stored Grain; in U. S. Dept. of Agric. Farmers' Bul. 1483, pp. 23—25.

Bromley, S. W. — 1928. Cyanogas Calcium Cyanide for the Fumigation of Flour Mills. American Cyanamid Co.

Chapman, R. N. — 1921. Insects Infesting Stored Food Products; in Minn. Exper. Sta. Bul. 198, p. 71.

Chapman, R. N.., and Johnson, A. H. — 1925. Possibilities and limitations of Chlorpicrin as a Fumigant for Cereal Products; in Journ. Agric. Res. 31, pp. 745—760.

Dean, G. A. — 1913. Mill and Stored Grain Insects. Kans. Agric. Exper. Sta., Bul. 189, pp. 145—176.

Goodwin, W. H. — 1922. Heat for the Control of Cereal Insects; in Ohio Agric. Exper. Sta. Bul. 354, p. 3.

id. — 1922. Heat for the Control of Cereal Insects; Ohio Agric. Exper. Sta., Bul. 354, pp. 1—18.

McDonald, R. E., and Scholl, G. J. — 1922. Disinfecting Cotton Seed to Prevent the Spread of the Pink Bollworm; in Texas Dept. of Agric., Bul. 71, pp. 1—38.

McDonnell, C. C. — 1911. Chemistry of Fumigation with Hydrocyanic Acid; in U. S. Dept. of Agric., Bul. 90, Part III, p. 96.

Neifert, I. E., Cook, F. C., Roark, R. C., and Tonkin, W. H. — 1925. Fumigation Against Grain Weevils with Various Volatile Organic Compounds.

Schenk, Gilbert. — 1926. Cyanogas Calcium Cyanide for the Control of Insects Infesting Grain in Storage Bins; American Cyanamid Co., Sec. 3, pp. 37—69.

Smith, Roger, C. — 1926. House Fumigation with Calcium Cyanide; in Journ. Econ. Ent., Vol. 19, pp. 65—77.

Strand, A. L. — 1926. Chlorpicrin for Mill Fumigation; in Journ. Econ. Ent. 19, p. 510.

id. — 1927. A Comparison of the Toxicity and the Diffusion in a Column of Grain of Chlorpicrin, Carbon Disulphide, and Carbon Tetrachloride; in Minn. Agric. Exper. Sta., Technical Bul., 49, p. 29.

Swanson, C. O., and Working, E. B. — 1926. How Fumigation Affects Wheat; in Millers' Review and Dixie Miller, Vol. XC, No. 2, pp. 28—30.

The Capsid Pests of Fruit Trees in England.

J. C. F. Fryer, M. A., Director of the Plant Pathological Laboratory, Ministry of Agriculture, Harpenden, England.

The subject of the Capsid pests of fruit trees is one which seems peculiarly appropriate to a Conference held ar Cornell, because that University has always been to the forefront in regard to Capsid research, and from it have come the valuable papers by Crosby, Leonard, Knight, and from the New York Agricultural Experiment Station, those of Parrott and Hodgkiss. As the following paper must be brief and be devoted essentially to the English aspect of the Capsid problem, there will be little opportunity of referring subsequently to the work of these investigators, or to that of such Canadian entomologists as Caesar and Brittain, and therefore, before passing on, it is desirable to record that the work of Canadian and United States investigators on the Capsid problem is greatly appreciated by their confrères dealing with a similar subject on the other side of the Atlantic.

The Capsid Bug problem in England is a large one, too large to deal with as a whole in the time which is available for this paper, and in consequence it seems best to select certain aspects for treatment — trusting that in the subsequent discussion others will be able to refer to those which have necessarily been neglected.

The aspects of the Capsid Bug problem with which it is proposed to deal specially are: (1) the development of certain species as serious pests, (2) the reactions of the plant to Capsid attack, and (3) the difficulties in controlling the injurious species in England.

1. The transference of an insect species from some wild host plant to a cultivated crop and the consequent change of that species from a status of little economic importance to that of a serious pest is, of course, an occurrence which is only too frequently observed, but in the majority of cases, I think, the species concerned has accepted the cultivated foodplant almost as soon as it has had the opportunity. The introduction of the Irish potato, for instance, into a new country has led to the speedy transference to that crop of certain insects which previously fed upon Solanaceous weeds: while as in an undeveloped country cultivation spreads further and further afield, so new species are constantly being brought into touch with crop plants and have then the opportunity of developing into pests. In such cases, therefore, it is only necessary to bring the insect and crop together for the former to develop into a pest. The circumstances in which certain Capsids in England have become pests are, however, different from such simple cases as these and are of sufficient interest to justify some consideration. For this purpose it will be sufficient to take the

two species which have become pests of serious economic importance, the Apple Capsid *(Plesiocoris rugicollis* Fall.) and the Common Capsid *(Lygus pabulinus* L.).

The Apple Capsid is an insect which is widely distributed throughout Britain, its chief wild food-plant being *Salix* (also *Ulmus, Corylus, Myrica* and *Populus):* it is never, apparently, found on any wild member of the *Rosaceae.* Somewhere between 1900 and 1910 one or two apple growers in the three chief fruit districts of England noticed an injury to the fruit or foliage which they had not seen before. Specimens were examined by Theobald, of Wye, and MacDougall, of Edinburgh, with the result that between 1910 and 1912 a number of different Capsids were regarded with great suspicion, although even then many authorities were not convinced that the injuries to the fruit were due to insects. The English Board of Agriculture, on the appointment of an entomologist in 1913, took the matter up and it was established that the cause of the trouble was *Plesiocoris* (1, 2), now known as the Apple Capsid, a result which was amply confirmed by Petherbridge and Husain, of Cambridge (3).

In 1913, the number of plantations experiencing trouble from the pest was small, although widely distributed, but since then there has been a continuous increase, until at the present time the Apple Capsid is perhaps the most serious pest with which English apple growers have to contend, though even to-day the distribution of the bug in apple orchards is still far from universal. Since the injury caused by the bugs is so great as to cripple the trees and render the crop unsaleable, it may be taken as certain that prior to 1900 *Plesiocoris* was not an apple pest in England and therefore the change in the status of the insect took place somewhere between 1900 and 1910. This change might theoretically have arisen in two ways: either an apple-feeding strain of the bug might have been imported from overseas, or the native willow-feeders might have discovered the apple as a potential food-plant. The first alternative can almost be ruled out, as in 1910 it would seem that *Plesiocoris* was only known as an apple pest in Scandinavia (4), a land from which England does not receive apple trees or stock, and even if an exceptional consignment had been received, it is impossible to suppose that infested trees from it would have been sent all over the country. By far the more likely alternative, therefore, is that the native willow-feeding *Plesiocoris* transferred their attentions to apple. This change appears to have involved some readjustment of the insect's life-cycle, since when living upon willow the species usually occurs rather late in the season, i. e., from June to August; whereas upon apple, hatching takes place from the middle of April onwards, and adults are found by the 1st June, and in general have died before the middle of July. The whole life-cycle appears, therefore, to have been pushed forward by about a month.

The change in food-plant did not stop at this point, for more or less simultaneously with the discovery of the bug on apple it was also found on currant, but strange to say in some localities it occured on currant and not on apple, even though the latter trees were interplanted between the currants. Unfortunately, by the time the discoveries were made it was already too late to investigate the circumstances under which these changes of food-plant occurred in nature, and all that could be done was to make

experimental transfers. Such experiments showed that the insects could, in the nymph or adult stages, be transferred readily from willow to apple or currant, from currant to apple, and even on to new food plants such as plum, only a slight or very temporary reluctance to attack the new food-plant being shown. On the other hand, a definite tendency for the insects to remain upon the host plant on which they had hatched is shown by the fact that in certain cases willow trees were found with their branches actually touching or interlacing those of an apple, yet although the willows were thoroughly infested, no transfer to the apple trees took place. This case, therefore, is evidently one of those which should be considered in connection with the hypothesis commonly known as the "Hopkin's Host Selection Principle" (5), but first a brief reference may be made to the second case to be cited — that of the Common Capsid, *Lygus pabulinus.*

This insect has been known as a minor pest of potato and other herbaceous plants for a great number of years. It was noted, for instance, according to Curtis's "Farm Insects" in 1846 (6) in connection with the potato and flowering plants in gardens, especially dahlias have long been known to be susceptible to damage. Some fifteen years ago, when *Plesiocoris* was first under investigation, *Lygus pabulinus* was occasionally found upon currants and gooseberries, causing damage very similar to that due to *Plesiocoris,* but at that time there was no mention of the insect in connection with apples. In an examination of some thousands of Capsids from apple, for instance, I never detected a *Lygus pabulinus,* and I think it may be taken as certain that about the year 1910 the species either did not occur on apple or was excessively scarce. Some three or four years ago, however, serious Capsid damage began to be observed late in the season, in August and September, after *Plesiocoris* had disappeared. Such damage also occurred on certain special demonstration plots in which the greatest care had been taken to destroy all *Plesiocoris* early in the season. Upon investigation it was found that *Lygus pabulinus* was responsible for the injury, and since then a fair number of cases of *Lygus* damage to apples have been detected. The life-history of the species has been worked out by Petherbridge and Torpe (7) and so far as the work has gone proves to be in great contrast to that of *Plesiocoris.* Whereas *Plesiocoris* is single-brooded and normally remains and oviposits on the trees on which it was hatched, *Lygus* appears to be double-brooded (possibly with a partial third brood) and has a strongly developed migratory instinct. The typical life cycle, from which departures are, however, frequent, appears to be as follows: — The winter eggs are laid in woody plants, such as the wild rose, or cultivated plants such as the currant, gooseberry, occasionally the pear, and now the apple. The insects hatch about the same time as the Apple Capsid, or a little later, but when about half grown they tend to migrate from the woody plant to any herbaceous plants growing near — as, for instance, to strawberries, potatoes, weeds of the genus *Chenopodium,* and many others. On becoming adult these bugs lay eggs upon the herbaceous plants — often, for instance, on potatoes when this crop is in the neighbourhood of fruit trees or hedgerows: these eggs hatch within a short time, and a second generation of bugs is produced, which, when adult, tend to return to woody plants in order to lay their eggs. This life-cycle, however, must not be taken as rigid, for throughout their lives the bugs

show a tendency to wander, and they may remain for longer or shorter periods away from the winter host-plant.

The case of *Lygus pabulinus*, therefore, is in marked contrast to that of *Plesiocoris rugicollis*, and the two together open up a very interesting field for speculation in connection with hypotheses of host selection. *Plesiocoris* appears to act in accordance with the "Hopkins's host selection principle" in that it tends to remain upon the host on which it was bred, but this tendency does not seem to be due to any nutritional difficulty in adapting itself to a potential alternative host, but purely to the fact that the bug has a slight disinclination to attempt to feed upon a strange plant. The desire for food, however, soon overcomes this disinclination to experiment, and the discovery that apple, for instance, is as satisfactory as willow follows immediately. So far there is no evidence whatever to show that continued breeding on one host increases or develops any disability on the part of the bug to feed upon a new host, and therefore *Plesiocoris* is different from the Cerambycids investigated by Craighead (8). The case of *Lygus*, however, is evidently more complex, for here the bugs which return to apple trees for depositing their winter eggs have lived throughout their lives on some herbaceous plant: they are compelled, for egg-laying, to select a new food-plant, and in their wanderings for this purpose they must frequently in the past have met with apple; yet it is only within the last fifteen years or so that they have discovered that apple is a satisfactory host. There is no evidence of the establishment of a strain definitely adapted to apple, and it therefore seems necessary to revert to some hypothesis involving an inherited memory. Clearly, therefore, the bionomics of these bugs are of interest not only from the economic standpoint, but also from that of biology in general.

It would not be appropriate in this paper so speculate further in regard to this aspect of the Capsid problem, but it is hoped that the mention of it may attract others to put in hand a carefully planned series of experiments with the Capsidae, a task which, however attractive, is perhaps more likely to be within the scope of an entomologist who is not too closely tied to the strictly economic side of his subject.

2. The second aspect of the Capsid Bug problem to which reference may be made, is the reaction of the plant to Capsid attack. When a young *Plesiocoris* punctures an apple fruitlet, the subsequent development of that fruit is wholly abnormal, and in bad cases the apple as picked may be a cracked and distorted object more like an ill-shaped potato than a proper fruit. Similarly, foliage or young shoot growth, when attacked by *Plesiocoris* or *Lygus*, is seriously injured — large areas of cells being killed and the subsequent development stunted or distorted.

The first remarkable thing about this damage is that it is confined to certain few species, essentially to *Plesiocoris* and *Lygus*, and that the other Capsids now living upon apple, e. g., *Atractotomus mali*, *Psallus ambiguus*, *Aetorrhinus angulatus* and *Orthotylus marginalis* — puncture the plant just as freely, but, so far as we have been able to ascertain, cause practically no damage. Of these species, the first three are typically feeders upon woody shoots of the *Rosaceae*, and their occurrence on apples is evidently normal, but *Orthotylus marginalis* appears to be another willow species which has migrated to apple, possibly within recent times. These

facts suggest at once that the injury is due not to material extracted in feeding, but to a specific poison introduced by the bugs, a suggestion which has been confirmed by K. M. Smith (9), who proved that the salivary glands of *Plesiocoris* and *Lygus* contain some substance which is intensely toxic to certain plant tissues. In the case of *Plesiocoris*, however, it is evident that the toxin which is introduced is not equally harmful to all its food-plants and, most suggestive, it is least harmful to *Salix*, the plant which we believe to have been the original food-plant. The tolerance or otherwise of the plant to the bug saliva is evidently in this case of a chemical nature, and it is hoped that some bio-chemist may take up the problem, for at present there appear to be little bio-chemical data upon which further discussion can be based.

Mention may next be made of what appears to be a definite resistance to the attack of a Capsid as opposed to the tolerance of the willow. It is not infrequently observed that trees in an orchard which is permanently covered by grass suffer less from the attacks of *Plesiocoris* than other adjacent trees grown in cultivated soil. The subject is still under investigation, but there are some grounds for supposing that the type of growth which is obtained in a grass orchard is less suitable to the Capsids than that of the tree in cultivated soil. There is a reduction in young wood and a shortening of the internodes in the tree surrounded by grass, and in consequence a hardier type of growth which may not improbably be less suitable to the bug, both for feeding and for egg-laying.

There are thus two salient points in the reaction of the plant to Capsid attack — (a) the salivary secretion of the bug is not equally toxic to all its potential food-plants, some of which show a marked tolerance, (b) a plant to which the saliva is most toxic may nevertheless develop a definite resistance to bug attack, by which it becomes a less suitable host-plant and carries a smaller bug population. In spite of the little information we possess in regard to it, this aspect of the subject has seemed worth mentioning, because it emphasises the need for studying the insect-plant complex rather than of treating the insect as an entity by itself without relation to the varying conditions of the plant on which it lives. Work from this point of view is attracting much more attention than was formerly the case, notably perhaps from the field ecological standpoint. It is suggested, however, that it merits even more attenion, and specially from the experimental standpoint. As an instance of the interesting results which may be obtained by such methods, Andrews's (10) work upon the tea Capsid *Helopeltis* may be mentioned, for although so far as I have heard this work has not yet found general economic application, nevertheless the mere fact that Capsid damage could be reduced under experimental conditions by the special application of a potash solution to the cut roots of a tea bush shows that discoveries of great economic importance may reasonably be expected from further research along similar lines.

3. The third aspect of the Capsid problem with which it is proposed to deal is the practical one of controlling these pests in orchards.

When the need first arose for a serious effort, the spraying programme for apples in the districts most affected consisted of a delayed dormant lime wash to control aphides and *Psylla*, followed if necessary by lead arsenate in the pink or pre-pink stage for caterpillars, and occasionally

by another application of lead arsenate as a calyx spray or later. Sometimes lime sulphur was substituted for lime wash in the delayed dormant application, but it was less effective against aphides and suckers. Some growers also used a pre-pink application of nicotine and soap in an effort to control simultaneously aphides, suckers and caterpillars.

The appearance of *Plesiocoris* in apple orchards, however, brought about considerable alterations in these programmes, for the old lime wash was found ineffective, and lime sulphur, of course, equallyuseless. A contact spray against the young Capsids was evidently needed, and as nicotine, especially during the war, became very expensive, very many alternative insecticides were tested, practically invariably with disappointing results, and in consequence attention was concentrated on nicotine, which in England is chiefly marketed as a 95% solution of the alkaloid and not as the sulphate. Under experimental conditions it was soon proved that a nicotine and soap spray was completely effective in killing the bugs, but it was also found that under full scale commercial conditions both the spraying technique and spraying apparatus of the average grower would have to be graded up considerably if satisfactory results were to be obtained. This demand was gradually met, and about five years ago it looked as if the problem of controlling the Capsid commercially was well on the way to a satisfactory, although an expensive, solution. The Capsid spray programme indicated was to give the first spray about ten days after the first bugs had hatched — approximately when the apples were passing from the pre-pink to the pink stage, with a second application if necessary shortly after the petals had fallen.

The control so obtained, however, has not proved altogether adequate to modern demands, and complaints are still received from growers, including the more skillful, that they are not getting sufficiently good results in their Capsid spraying, and so far as can be judged this is due to the effects of the weather upon the hatching of the bug. The English climate, or rather the lack of it, is notorious, and it usually happens that prior to and during the flowering period of the apple, alternate very cold and very warm spells occur: this alternation influences the bugs so that hatching is spread over a very long period, possibly a month or five weeks. The weather during this period usually renders it difficult to spray under favourable conditions more than once, not always that, and the grower has therefore great difficulty in doing the work at the right time. If he sprays too soon, more bugs emerge before he is able to get round with his spraying tackle again, while if he is late, much damage will already have been done.

The Apple Capsid is therefore presenting a stiff problem to the apple grower at present, and his task is likely to be still heavier if the migration of *Lygus* to apples becomes more general. In this case he may get a complete kill of the Apple Capsid and the Common Capsid by his spring treatments, and again find himself faced by infestations of Common Capsid later in the summer, the bugs migrating back from herbaceous plants and weeds. The Common Capsid is also more difficult to deal with by spraying than the Apple Capsid, as it more readily jumps or falls from the trees when disturbed by spraying: many bugs are thus missed unless the ground be also heavily sprayed or the trees banded.

The spraying problem thus presented for us in England is therefore a difficult one, especially as we have Apple Scab to deal with at about the same time and the type of spraying work required for Capsid control is emphatically not that suited to Scab, even if the ideal combined insecticide and fungicide be discovered. Under these circumstances, fruit growers have naturally asked themselves whether it is not possible to control Capsids by some form of winter wash, as, for instance, by one of the tar distillate egg-killing washes which have now been adopted as the routine washes for winter use, since they are entirely successful in dealing with aphides and apple suckers, and reasonably effective against the eggs of moths. On the face of it, such a treatment would appear almost hopeless, as the Capsid eggs are completely inserted in the twigs, and so should be very largely protected from the effects of any insecticide. In spite of this, however, Frost (11) showed in 1925 that in Pennsylvania the partial destruction of the eggs of the Apple Red Bug could be obtained by the use of a delayed dormant oil spray, and in England the experimental results of winter washing, although irregular, have been of great interest. Up to last year, in the course of numerous trials in the Cambridge district, practically no success was obtained, but in one or two cases in the West Midland area, quite definite results in controlling the Capsids were claimed. This year further trials have been made in the Cambridge area, and the results have still been useless from the commercial standpoint, although the treated plots in some cases were definitely better than the checks. On the other hand, in the West Midlands in two cases a full commercial control has been obtained by experimenters from the Long Ashton Fruit Station, using a standard tar distillate which they had evolved. The results were very remarkable, and were equal to those obtained by the best nicotine spraying — indeed, the growers concerned say they no longer fear Capsid. Again, in another experiment carried out by Theobald, of Wye, in Kent, mots hopeful results were got with some five commercial brands of tar distillate wash, and here again the grower believes that the Capsid problem has been solved.

The discrepancy between almost complete success and nearly complete failure is therefore very remarkable, and this is the point to which attention is now being directed. Since possible variants of an obvious character, such as time of spray application and strength of wash, have been practically eliminated, it is necessary to investigate more obscure factors which might have some bearing on the result, and perhaps the most likely of these factors is the depth in the bark to which the egg is inserted. It may be, for instance, that in growth of a certain type the egg may be forced into the bark to a considerable depth, while in another type they may almost project and so exhibit sufficient surface to absorb the insecticide. However this may be, it is now demonstrated that Capsid Bug eggs in the bark of an apple tree can be killed by winter treatment, and with more knowledge of the factors involved it is hoped that it may prove possible to deal with Capsids along these lines.

For our Capsid control in the immediate future, therefore, we are looking (a) to still greater improvement in spraying technique so that the spring application may be made more rapidly and with greater effect, and in this connection the demand for a cheaper insecticide than nicotine has

not been forgotten, (b) to evolve a method of killing the eggs in the winter, a task which is clearly not so hopeless as it looked at first sight. In the more distant future, however, it is not perhaps unreasonable to look forward to the control — or at all events partial control — of Capsids by other means than the direct application of insecticides, as, for instance, by enabling the trees themselves to withstand the attack. But in order to achieve this end we need the help, not merely of the economic entomologist, but of entomology in general, for it is clear that success can only come through a very much greater knowledge than we now possess of the many factors influencing the habits or behaviour of insects in general and Capsids in particular. The activities of the economic entomologist are very largely governed by the demands of the public at the moment, and he is necessarily drawn to seek an immediate solution of any difficulty, but the entomologist in general has a freer hand, and he can give his economic confrère the greatest help if he directs his attention to such problems as are instanced by the Capsid, problems which in themselves are not economic, but are of the widest biological importance — a note upon which this paper may well be ended.

Literature.

1. J. C. F. Fryer. — 1914. Annals of Applied Biology, Vol. I, p. 107: Preliminary Notes on Damage to Apples by Capsid Bugs.
2. J. C. F. Fryer, and F. R. Petherbridge. — 1917. Journ. of the Board of Agriculture, Vol. XXIV, p. 1: Report on Further Investigations on the Capsids which attack Apples.
3. F. R. Petherbridge, and M. A. Husain. — 1918. Annals of Applied Biology, Vol. IV, p. 179. A Study of the Capsid Bugs found on Apple Trees.
4. Schøyen. — 1914. Beretning om Skadeinsekter og plantisygdommer i land og havebrukt.
5. A. D. Hopkins. — 1917. U. S. Dept. of Agriculture, Program of Work 1917, p. 353, and Walsh 1864—63 Proc. of Ent. Soc. Philadelphia, III. p. 403, V. pp. 194.
6. John Curtis. — 1883. Farm Insects, p. 436.
7. F. R. Petherbridge, and W. H. Torpe. — 1928. Annals of Applied Biology, Vol. XV. p. 446: The Common Green Capsid Bug *(Lygus pabulinus)*.
8. C. F. Craighead. — 1921. Journ. of Agricultural Research, Vol. 22, p. 189: Hopkins' Host-Selection Principle as Related to Certain Cerambycid Beetles.
9. K. M. Smith. — 1920. Annals of Applied Biology, Vol. VII, p. 40: Investigation of the Nature and Cause of the Damage to Plant Tissue Resulting from the Feeding of Capsid Bugs.
10. E. A. Andrews. — 1923. Factors affecting the Control of the Tea Mosquito Bug *(Helopeltis theivora)*. Published by the Indian Tea Assocn.
11. S. W. Frost. — 1925. Journal of Economic Entomology, Vol. 18. p. 516: The Delayed Dormant Oil Spray for Killing Apple Red Bug Eggs.

The Insect Fauna of Thermal Springs.

Charles T. Brues, Bussey Institution, Harvard University, Cambridge, Mass.

Thermal springs, more commonly known as hot springs, are those in which the temperature of the water is above the mean annual temperature of the localities at which they occur. In some cases the water is no warmer than that of small ponds during the summer time, but in the majority the water is considerably hotter and in frequent cases emerges from the earth at a temperature near the boiling point. The water of thermal springs may in some cases be derived from meteoric water which has passed through heated rocks, or it may be juvenile or magmatic water which is formed during the cooling and crystallization of molten rocks as steam which is condensed into water before it reaches the earth's surface. It is probable that the water of many hot springs is entirely magmatic in origin.

Hot springs are widely scattered over the earth's surface, particularly in regions which are now volcanically active or which were active during Tertiary times. There are some well-known hot springs in Europe and New Zealand and a great number occur scattered through the western United States. The largest group in the world is in Yellowstone Park, which includes also many large intermittent boiling springs or geysers.

The temperature of most hot springs is very high, but as the water usually flows off in a stream of some sort, it cools gradually and thus offers a series of stations which are suitable for the existence of animal and plant life of many kinds. Aside from its high temperature, the water generally contains noticeable amounts of salts in solution, which increase ist specific gravity and osmotic pressure. Thus the specific gravity commonly ranges between 1.001 and 1.003, although it may sometimes be much higher. The saline constitution varies greatly, including usually the chlorides of sodium and other metals, frequently sulphates and carbonates, and its composition does not ordinarily approach closely to that of sea-water. The hydrogen ion concentration varies greatly also, generally between 6.0 and 9.5. In the more acid waters carbonic acid gas and hydrogen sulphide may be present and in the presence of the former considerable amounts of calcium carbonate are usually dissolved, the lime being rapidly deposited from solution to form calcareous incrustations of travertine about the springs. If the water is more alkaline, usually due to the presence of sodium carbonate, silica may be present in solution and deposited as incrustations of sinter from the cooling water. There is often an unusually small amount of oxygen dissolved in the water.

As a biological environment, it is therefore evident that hot springs differ from the ordinary fresh water pond or stream in three important

respects: 1st, an abnormally high and constant temperature; 2nd, the presence of certain salts in solution in considerable amounts and greatly varying proportions; 3rd, by a quite consistent deficiency of oxygen in solution and frequently by a great excess of carbon dioxide or hydrogen sulphide. All of these factors are important in determining the character of the fauna.

There is a great range in the tolerance of aquatic organisms to heat. Certain blue-green algae which occur in hot springs are found commonly at temperatures of between 60° and 80° C and occasionally at higher ones, especially in water of high pH. Green algae are less resistant and the higher plants rarely or never occur at temperatures above 52° C.

Among animals, the range of tolerance is far less and ranges between 30° and 50° or 51° C. The lower limit, of course, passes over without break to the temperatures which prevail in ponds of non-thermal origin, except that there is little or no diurnal and a greatly reduced annual variation. Water at the higher temperature levels is only very sparsely populated by a few extremely resistant forms, but the occurrence of animal life at 45° to 46° C is not infrequent.

Protoza of a number of types occur in hot springs and certain lowly organized fresh-water types of invertebrates, such as flatworms, nematodes and annelids are occasionally encountered.

There are a number of Crustacea, such as *Cypris,* and certain Amphipods belonging to *Gammarus* and related genera widely distributed in hot springs. Among the Arachnida, at least one genus of mites, *Thermacarus,* appears to be restricted to hot springs, as it has been found only in this habitat, in Siberia near Lake Baikal and in the South-western United States. A few other mites are also known to live in hot springs.

The bulk of the fauna consists of insects, among which numerous members of the orders Diptera, Coleoptera, Hemiptera and Odonata are included.

The Diptera include representatives of a series of widely dissimilar groups. The most abundant flies that develop in thermal springs are members of the families *Chironomidae* and *Ceratopogonidae.* In the hot springs of the Western United States the writer has found larvae belonging to several genera in water ranging from 39° to 43° C and in one case at a temperature of approximately 50°. Many of these midge larvae are red in color, due to haemoglobin in the blood, and it seems certain that these blood-worms are for this reason able to live in water which contains unusually small quantities of dissolved oxygen.

The larvae of a few species of mosquitoes occasionally occur in thermal springs water of comparatively low temperature. In the Western United States *Culex tarsalis* Coq. is the most abundant form, breeding in water as hot as 39° C. This is an alkaline water species which I have encountered only in water of high pH (7.9—9.4).

Members of the family *Stratiomyiidae* develop very commonly in thermal water, where I have collected representatives of four genera: *Stratiomyia, Odontomyia, Oxycera* and *Nemotelus.* These larvae are highly resistant to heat and have in a number of instances been taken in water between 43°—47° C. As they require water containing appreciable quantities of lime, they appear to be restricted to water of comparatively low pH (6.0—8.0), none having been reported from the more alkaline springs.

They are also very resistant to the presence of salts in solution, one species of *Odontomyia having* been taken in water with a specific gravity of 1.021.

Although the *Tabanidae* are not typically members of the hot springs fauna, their larvae often occur in water at temperatures of 43° and below. One species, *Tabanus punctifer* O. S., which breeds abundantly in alkaline ponds throughout the Western United States, frequently invades thermal waters.

The *Syrphidae* are represented so far by a single species of *Eristalis*, whose larva appears to be closely related to *E. (Lathryophthalmus) aëneus*. This form can hardly be considered as a member of the true thermal fauna, since it has not been found in water of more than 33.3°.

Larvae of brine-flies of the family *Ephydridae* are well known inhabitants of salt pools and brackish water, and species of *Ephydra* have been reported from hot springs in several parts of the world. The writer has found them in a number of springs in the Western United States, in one case extending into water at 43°.

Coleoptera of several families live very commonly in thermal water, several species occurring at temperatures between 45° and 46° C. As might be expected, the majority of the thermal beetles are members of the *Dytiscidae* and *Hydrophilidae,* but there are also a few *Gyrinidae, Haliplidae, Helmidae* and *Heteroceridae,* none of which appear to enter water of more than 40° or thereabouts. Many of these species of beetles are known to pass their preparatory stages in the hot springs, but so far as is known none of the larvae appear to be so resistant to high temperatures as the imagines of some forms. Among some seventy records relating to thirty-one species of aquatic Coleoptera collected by the writer in hot springs in the Western United States the reduction of the beetle fauna by rising temperatures is shown to be a gradual and continuous process between temperatures of 32° and 46°.

Certain aquatic Hemiptera are known from hot springs, but none of the members of this order are so well adapted to life at high temperatures as are those of the orders previously mentioned. They include mainly *Naucoridae*, *Corixidae* and *Notonectidae*.

Odonata are abundant and the nymphs of a number of species occur very generally in warm or hot springs, in some cases at temperatures well above 40° C. Nymphs of the widespread *Mesothemis simplicicollis* invade water of 43°, which seems to be the highest record not open to suspicion for any dragon-fly.

Members of other orders are practically absent from the hot springs fauna, which is as might be expected, since the vast majority of aquatic insects belong to the groups already mentioned. The scarcity of Trichoptera is, however, very noticeable.

In addition to the insects and other invertebrates just mentioned, a number of molluscs are members of the thermal fauna, in this country more particularly members of the abundant genus *Physa*.

Among vertebrates, a few fish and occasionally anurous batrachians have been taken in hot springs, but their upper limit of tolerance is comparatively low in comparison with insects, as it ranges very close to 40° C.

The composition and distribution of the thermal fauna are of considerable interest from a more general biological standpoint. Its composition shows at once, at least so far as insects and all the higher forms of animal life are concerned, that the thermal fauna is in no sense a primordial or primitive one, but that it has originated by the migration of a great variety of fresh-water types into hot springs in comparatively recent times. Only a very few of the genera and species so far known appear to be restricted to thermal water of comparatively high temperature.

The tolerance of insects and other animals in hot springs is in close accordance with experimental studies on the lethal temperatures for a variety of species which do not normally occur in a thermal environment, although it indicates that there has been some acclimatization to the deleterious effects of heat among the members of the hot springs fauna. This is also in agreement with the fact that certain desert insects and those which live in the subcortical tissues of logs, where they are subjected to unusually high temperatures, exhibit also a small but noticeable increase in tolerance to heat. The possible range of acclimatization, however, is limited to a very few degrees in animals and higher plants. This fact, together with others elsewhere set forth, have led the writer to believe that the destructive effects of heat to protoplasm are due to its action upon the mitochondria, which are characteristic of all the organisms that do not extend their tolerance above a range of from 45^0—50^0 C.

A comparison of the composition of the hot springs fauna with that of the sea and of brackish water reveals a close similarity. This is no doubt due to the generally high specific gravity and osmotic pressure of the water in hot springs. Thus the same fresh-water types, on account of their tolerance of a saline medium, have migrated both into hot springs and brackish water, where they have become established as characteristic members of the maritime or saline lakes fauna.

Cotton Insect Problems in the United States.

B. R. Coad, Bureau of Entomology, U. S. Department of Agriculture, Tallulah, Louisiana.

The average American cotton grower usually feels that the trials and suffering's of Job are as nothing compared with his tribulations in trying to prevent insects from destroying his hard earned cotton crop, and a review of his insect problems certainly leads one to feel that he is not without some justification in this attitude. From the time the seedlings are out of the ground until the crop is finally matured, the cotton plant is constantly beset by hungry hordes of insects, and as the years go by with more and more intensive culture, these insect problems increase rather than decrease. Anything like a comprehensive review of the subject of insect activities on cotton would occupy volumes and the purpose of the present paper is to touch only briefly the most important problems and to show something of the conditions confronting the cotton grower. At the outset it should be remembered that cotton is grown in the United States in an area extending over 2,000 miles from East to West, and 600 miles from North to South. Within this area we find a tremendous variation of conditions as regards climate, soil, topography, altitude, etc., and these varied conditions are naturally reflected in the insect problems in the different districts so that a problem which is acute in one portion of the cotton belt can be of minor importance or even non-existent in another portion.

1. The Boll Weevil.

The most famous, or, more properly, the most infamous of cotton insects in America is, of course, the cotton boll weevil. This unwelcome visitor invaded the United States nearly 36 years ago and marched onward year after year until it now covers all portions of the cotton belt where conditions are at all suitable, this area comprising over 90% of the cotton producing acreage. Throughout this area it is an ever present menace, but the amount of damage varies exceedingly with the locality and season. Some districts suffer serious damage every year; in other districts the weevil has never been able to do more than barely maintain itself. Between these two extremes we find every gradation of damage and the most important problem is that large area of fluctuating damage, where weather conditions unfavorable to the weevil hold damage to a minimum, but where a few weeks or even a few days of favorable weather cause a sudden acceleration in weevil activity and an enormous increase in damage.

The spread of the boll weevil has revolutionized cotton production in the United States. Many cotton varieties not adapted for weevil conditions

have absolutely disappeared from existence. Cultural methods, farm methods and even farm economics have been changed completely, and out of all this chaos has arisen a program of better farming and sounder agriculture than existed before the weevil arrived. Undoubtedly, such an evolution would have been forced by economic conditions regardless of the weevil, but the advent of this pest expedited the change. The whole program of cotton production in those areas where the weevils are most active is now aimed at answering the big problem of producing cotton with a minimum of weevil damage. Early maturing varieties with the minimum vegetative growth and the maximum development of fruiting have been adopted; better culture is used, with more careful and more frequent cultivation; the plants are spaced closer, and fertilization either by rotation or by artificial fertilizers has taken an important place in many areas where it was never before considered necessary. The aim of all of these practices is to produce the maximum amount of fruit in the shortest possible time, and these practices alone suffice under some conditions, but there is also the enormous area where they are not sufficient and additional direct control measures are required.

After many years of experimentation, weevil control by the use of poisons finally reached the point where it could be recommended for use by the growers. This consists primarily of applications of powdered calcium arsenate in the form of a dust cloud. This was first utilized commercially in 1919 and spread rapidly until 1922: then followed several dry years with a high climatic control of the weevil and comparatively slight damage, so that there was not such serious need for poisoning, and during that period the acreage treated remained more or less unchanged. Since then, with more normal conditions and weevils again becoming active, there has been an increase in poisoning, and there is no question that the season of 1928 will see much more acreage poisoned than ever before. Generally speaking, the method has been at least reasonably satisfactory and highly profitable. It is not equally adapted to all sections, but the best feature of it is the fact that it is most suitable for those sections with heaviest weevil damage, and those climatic conditions causing the maximum weevil injury are also generally most favorable for maximum control by poisoning. One of the primary problems now is the adaptation of this method to those other districts with intermediate damage and somewhat less favorable conditions for poisoning. The extent of the infested area is so enormous and the variation in the problem presented in different districts so great that it will be many years before this method can be said to be out of the developmental stage, but each year methods are improving and profits becoming greater.

2. The Arizona Wild Cotton Weevil.

One of the outstanding characteristics of the cotton boll weevil is the fact that it cannot thrive under arid conditions, so there was a large area left in the West where these insects were not able to maintain themselves, and this area was looked upon as probably safe from weevil depredations. Consequently, it is easy to understand the consternation which followed the discovery of a boll weevil, obviously an offshoot from the same parent

stock, living on a wild cotton plant in the mountains of South-east Arizona. This was first found about fifteen years ago, and it was quickly determined that this variety of boll weevil would transfer to cultivated cotton whenever the opportunity offered, and furthermore, that it had become peculiarly resistant to the arid conditions. Various efforts have been made to stamp it out in nature, but in the light of present information it has been decided that such a procedure is impossible. In the meantime, with the tension of cotton production in that territory, this weevil has transferred its attention to cultivated cotton in at least three counties in South-eastern Arizona, and the main problem now is the one of preventing spread to other areas. Fortunately, cotton is grown in only limited isolated districts in these counties, and the infested zone includes only a few thousand acres of cotton. The present program is aimed at holding the weevils to a minimum in numbers and surrounding this zone with quarantine measures for the purpose of preventing spread to other districts.

3. The Cotton Leaf Worm.

Probably the oldest known pest of cotton in the United States is the cotton leaf worm, or as it is commonly called, the cotton caterpillar. A peculiar feature of this insect is the fact that it cannot pass the entire year in this country, as there is not yet a single record of its successfully surviving the winter in the United States. Consequently, its activity in the United States is caused by migrating flights of moths which travel in enormous numbers from the native home in South or Central America. Another peculiar feature is the fact that this species does not reach the United States every year. A study of past outbreaks shows that for a long period these flights seem to run in cycles. Years of maximum infestation in this country occurred about every 21 years with 2 or 3 years of increasing damage prior to this year, and 2 or 3 years of decreasing activity following this year; during the remaining period this species would not be seen in the United States. Apparently, something has happened to disrupt this cyclic occurrence, and the last great outbreak which reached its crest in 1912 was followed by an unexpected re-appearance of the worms in this country during the past half dozen years. Under the circumstances, there is considerable doubt as to just what we may expect in future outbreaks.

The normal procedure in years of invasion is for the worms first to appear along the Gulf Coast of South Texas, and for a month or more the area involved is generally comparatively small; then another generation follows and they sweep onward; usually by the third generation they cover a major portion of Texas, Louisiana, Arkansas and Mississippi and, in extremely bad years, cover the greater part of the cotton belt. Damage from this insect is very easy to eliminate by the application of an arsenical poison to the leaves of the cotton. The main problem is the one of anticipating when and where the outbreaks are going to occur and of having an ample supply of poison available when needed, since the acreage involved is so large and the progress of damage so rapid that it is practically necessary to have poison supplies available in advance successfully to avoid damage from an outbreak. For this reason, the efforts

of this Department are now aimed at perfecting methods of predicting time and place of outbreaks.

4. The Cotton Boll Worm.

The cotton boll worm or corn ear worm is another old time pest of cotton. It is usually most injurious in the western areas, particularly in Texas and Oklahoma, but during recent years has been increasing considerably in importance as far eastward as the Mississippi Valley and possibly even more to the East. This insect is ever present in limited numbers and each year takes some toll from almost every cotton field; however, severe damage from it is exceedingly sporadic and is not regular in any one district. Such control as is practiced, is generally that of cultural methods, but poison is utilized in extreme cases. The greatest problem in utilizing direct control measures is due to the irregular occurrence and the fact that no one knows just when or where to anticipate damage until it has actually developed. The grower who suffered serious damage last year may make all preparations for control this season and find that he has no boll worm activity whatever, and thus become discouraged from any future preparation for control. The general tendency now is to attempt to combine boll weevil and boll worm control in those districts where both insects occur and to utilize such a system that damage from both is checked by the same treatment.

5. The Cotton Aphis or Louse.

The cotton louse occurs in practically all sections of the cotton belt, but its injury is purely dependent on local conditions, and as a result it is not looked upon as a major pest. On seedling cotton in the early spring, particularly if the weather is cool, the lice multiply rapidly and may reach the point where they kill many plants and stunt and deform many of those surviving. This loss of stand and retardation of growth can easily become quite serious, especially in those districts of heavy boll weevil activity. As a rule these spring infestations are controlled by natural conditions including climatic factors and natural enemies, and while the lice are present practically all season, they become abundant enough to cause injury to the larger plants only under extremely favorable conditions. One interesting feature has been the fact that under certain conditions the use of dust insecticides on the cotton plant actually causes an increase in louse infestation and occasionally this increase develops to the point of damaging the crop. This increase is caused by a peculiar preference the lice have for any cotton covered by a whitened powder and also by the fact that this powder may kill certain of the natural enemies. A record of poison operations over a long series of years shows that this increase follows poisoning only when conditions are exactly right, and that it may be expected on the average only from 2 to 5% of the time.

Effective louse control is comparatively easy with suitable applications of nicotine dust, and in those cases where the infestation has become a complicating factor with weevil control the situation is met by adding nicotine to the calcium arsenate which is being applied to the plants.

6. The Cotton Flea Hopper.

About 10 years ago we began to hear of a peculiar damage to cotton plants in South Texas which resulted in deformed plants and shedding of fruit, with frequently very serious damage to the resultant crop. This injury has now been designated by the title of "flea-hopper damage" and more recent studies show that it is due to several different species of small sucking insects, but since the damage is apparently more or less identical it is considered collectively under the same general title. Since that thime sporadic occurrences have been recorded from practically every cotton state, and this finally culminated in 1926 in a widespread outbreak almost covering the entire main cotton belt. The exact nature of this injury is, of course, undergoing thorough investigation, but there are comparatively few final conclusions available as yet. Evidently, we are dealing with a complication of numerous factors involving presence or absence of other host plants and other conditions which may be favorable or unfavorable for the multiplication of these particular species of insects. Furthermore, the exact nature of the injury, whether toxic or otherwise, transmitted to the plant by the insect is still unknown. Generally speaking, this injury occurs in the early season and ceases suddenly with the maturity of the insects and their transfer to some other host plants which may become available. However, in extreme cases it may continue throughout most of the season, and even in those cases where the damage is confined to the early season; it is frequently quite a serious problem because of the loss of this early fruit, which is ordinarily the safest fruit to make in the presence of boll weevil.

It has been found that effective control can be secured by dust applications of powdered sulphur, but it is hoped that, when the present research has reached its completion, it will be possible to lay out much better control programs than are available at present. It is obvious that this damage is at least potentially exceedingly serious, and every effort is being made to carry the research to a thorough understanding of the entire problem.

7. The Pink Bollworm.

Every effort has been made to prevent the pink bollworm from entering the United States, but nevertheless numerous outbreaks have occurred as the natural result of its establishment in Mexico, which occurred about 1914. In 1917 several areas of infestation were found in Texas and from that time onward the United States has never been completely free of this pest. Those outbreaks which occurred in the main cotton belt have been stamped out by drastic eradication methods, but from the Mexican border, where there is constant reinfestation from Mexico, there has been a gradual spread which has reached the point where we now have approximately a half million acres of cotton in Texas, New Mexico and Arizona known to be infested by the pink bollworm. Hope has not been abandoned for complete eradication, and every effort is being made to prevent or at least retard spread. As far as actual crop damage is concerned, this species has become abundant enough to produce a marked loss only in a few hundred acres in what is known as the Big Bend area

of Texas, but the development of worm abundance in this area has permitted the establishment of an extensive research organization for the purpose of studying this species under the new conditions of American cotton production with a view of attempting to develop improved methods of repression and possible eradication.

8. The Cotton Leaf Perforator.

The cotton leaf perforator is peculiarly a western species; records show its occurrence from California eastward to extreme South Texas, but so far it has been injurious only in irrigated districts, and by far the most serious injury has been in the Imperial Valley of California. Here again we are confronted with a difficult control problem because of the sporadic nature of outbreaks. Several years will pass without damage and then suddenly we have very serious damage. It was only during the past few years that this damage became sufficient to warrant intensive research investigations, and while these are not complete as yet, favorable results have been indicated and it is possible that with a more thorough understanding of the conditions causing such outbreaks, they can be prevented without making it necessary to resort to direct control measures. Furthermore, preliminary tests have indicated the possibility of favorable results from the use of insecticides, particularly some of the fluosilicates and nicotine preparations.

9. The Cotton Red Spider.

A number of years ago the red spider attracted considerable attention, especially in the South-east, and it was found that damage from this species can quite easily be reduced by eradication of other host plants. Furthermore, in those cases where injury becomes severe on cotton, an effective control can be secured by certain sprays or by the use of dust applications of sulphur. Marked injury from this species rarely occurs over any very large area and is usually confined to localized districts, which may often be traced to the presence of a convenient supply of some other host plant. While more prevalent in the South-east, occasional outbreaks are encountered as far west as the Mississippi Valley with a few extreme records even west of that district; however, these seldom assume very much importance and are practically never encountered except under conditions of extreme drought.

10. Square Borer.

The cotton square borer is found practically throughout the cotton belt and is undoubtedly present in the majority of fields every season. When the cotton first starts squaring, these worms become active, and each year many growers become alarmed upon finding these worms boring into fairly large numbers of squares in the field. This frequently results in a desire to utilize some control measure, but it is always found that just about this same time parasitic control suddenly steps in and practically eliminates this worm from the picture, so that the fear of severe damage is really without foundation.

11. Miscellaneous Cotton Insects.

In addition to the foregoing insects which have been considered separately, there is a multitude of others which are either of minor importance or important only very locally. However, in the aggregate these always take a considerable toll from the cotton crop and here and there, every year, one or the other of them becomes of serious importance. In this group we have such pests as the cut worms, which destroy seedling cotton and later feed on the terminal buds of the young plants, causing deformed and retarded growth. Miscellaneous beetles feed on the plants, on the flowers and on the fruit; the fall army worm or grass worm on occasion becomes abundant enough to move through the fields in true army worm style; grasshoppers are an ever present pest and especially in the western areas become so serious that they require poison for control. We have also dozens and dozens of miscellaneous caterpillars and other lepidopterous larvae which feed on all portions of the plant. In addition we have the cotton stainer, boll bugs, sharpshooters, leaf hoppers and other sucking insects, sucking the sap from different portions of the plant. Wire worms, root lice and other similar pests prey upon the roots, and stalk borers bore into the stems. Fortunately, many of these insects are more or less automatically controlled by measures aimed at other major pests, but every time the grower reaches that happy frame of mind where he thinks he knows just what to do for his cotton pests, some new one of these minor pests suddenly develops serious activity in his fields, and he is thus confronted with a new problem. Fortunately, all of these insects do not occur in the same field every year, or cotton production would be a thing of the past, but the fact remains that, in many districts at least, the cotton goes through a cycle of pests and it is not unusual to see a grower dusting in the early season for hopper control, then later for boll weevil and still later for leaf worm and louse control. The net result is that it takes either a habitual gambler or a first class optimist to raise cotton in these areas.

The Value of Quantitative Methods in the Investigation of Field Crop Insects, with Special Reference to work with Wireworms and Cutworms.

Kenneth M. King, M. Sc., Entomologist, Saskatoon, Saskatchewan.*)

(With 2 text-figures.)

The recent furtherance of the investigation of problems in genetics made possible by the application to them of the new X-ray method, is but one more instance of the truth of the axion that new instruments and new modes of technique may be as productive of advances in science as generalizations that point the way for many investigations**). Yet, in looking over the general field of science, it is seen that the significance of this important truism is frequently overlooked and that promising new methods of approach are left for lang periods largely untested.

A noteworthy instance of this has been the slowness with which the new technique of population studies, or general quantitative field methods, have been applied to investigations in economic entomology. The pioneers both in plant and animal ecology, and their successors, have on occasion stressed in general terms the certain usefulness of these methods in economic studies. In a few investigations, population studies of individual insect pests have been made, but only rarely has general animal census work been undertaken.

In taking up at this time a consideration of the application of these methods to the study of economic problems connected with invertebrate pests of field and garden crops, it is, then, chiefly in the hope of adding definite, detailed, concrete illustrations of promising avenues for the employment of such methods.

Since their inception, six years ago, the present field crop insect investigations at the Dominion Entomological Laboratory, Saskatoon, have employed this new technique. In essence, this work is an application to economic problems of the quantitative field methods of plant and animal ecologists. In two important particulars, the fact that work has gone forward simultaneously both in several cultivated fields and in several areas of native vegetation, and that the periodic samples have been taken continuously in the same situations over a period of several years, the investigations at Saskatoon appear to be at present unique. At first, this census work included only four fields, but at present twelve situations, often differing in but one important factor, are under survey. Nearly six hundred

*) Contribution from the Division of Field Crop and Garden Insects, Entomological Branch, Department of Agriculture for Canada.

**) C. F. Curtis, Science (N. S.) LXVIII, 1782, pp. 141—149, 1928.

general samples have already been taken in the six years of investigation. These have been supplemented by more than one thousand special samples of various kinds, many of them relating particularly to the cutworm and wireworm studies. For example, annual wireworm censuses are being taken at present in 22 fields infested by these pests. There has thus been accumulated a very great mass of data, which it would be out of the question to present, even in summarized form, in the present discussion, but which are appearing from time to time in various papers.

Your permission is therefore requested to touch here only upon the "highlights" and broader conclusions from the work, with little immediate reference to the detailed supporting data, dealing first with the results of the general population studies and then with the special applications to cutworm and wireworm problems.

General Population Studies.

Methods. — The technique employed in the general population studies may be epitomized as follows: A continuous census is obtained, in each field under investigation, by means of quantitative samples repeated at approximately fortnightly intervals throughout the season of insect activity, the work each year closely duplicating that of each preceding year. Each sample includes the invertebrates of the soil, the surface, and the vegetation, the material being secured and examined by methods which are sufficiently standardized as to make the results each time closely comparable; in addition, the absolute accuracy is fairly high, except for those forms so small as to be barely visible to the unaided eye. Records of plant conditions and measurements of factors of the environment are maintained.

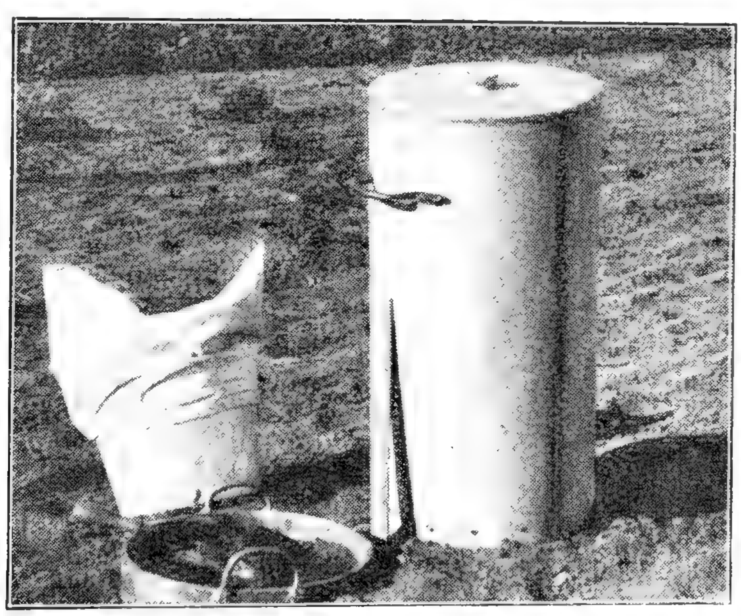


Fig. 1.

In greater detail: — In each situation decided upon for study a general sample area is selected. This is a piece preferably of one or two acres in size, in which the vegetation, soil and other discernible factors are as uniform as possible, and surrounded by a larger area also typical of the condition to be studied. Within the general sample area an individual location (each a few yards square) for each of the samples planned during a year, is allotted by measurement, within which small space the actual sample is located by chance at the time of taking. Beginning as soon as the soil thaws in the spring, the samples are regularly taken at the predetermined time until freeze-up in the fall. Each succeding season each sample is taken in the same

individual location used for the sample of that date in previous years. For convenience in conversion, the area of the sample has been chosen at $1/_{40,000}$ part of an acre, or almost exactly $1/_{100,000}$ part of an hectare; this is approximately $1/_{10}$th square foot. The time of sampling is at daybreak when active invertebrates are most quiescent and most uniform in condition from day to day.

Each sample is delimited by suddenly grounding a tall closed-top cylinder (Fig. 1) into the ground and around which ether is then poured. It is then replaced by a low ring enclosing an equal area. The vegetation, surface material and the soil in layers, are then removed in separate closed containers. The soil by layers is washed by water through sieves (Fig. 2), the final one covered with fine copper strainer cloth of exactly 50 meshes to the linear inch each way. The residues and other material are thoroughly examined, that of the surface debris, when heavy, being facilitated by use of a Berlese funnel. The sampling technique includes measured sweeping with an insect net, taken at the same time as the other material, the whole being calculated upon a population-per-acre basis.

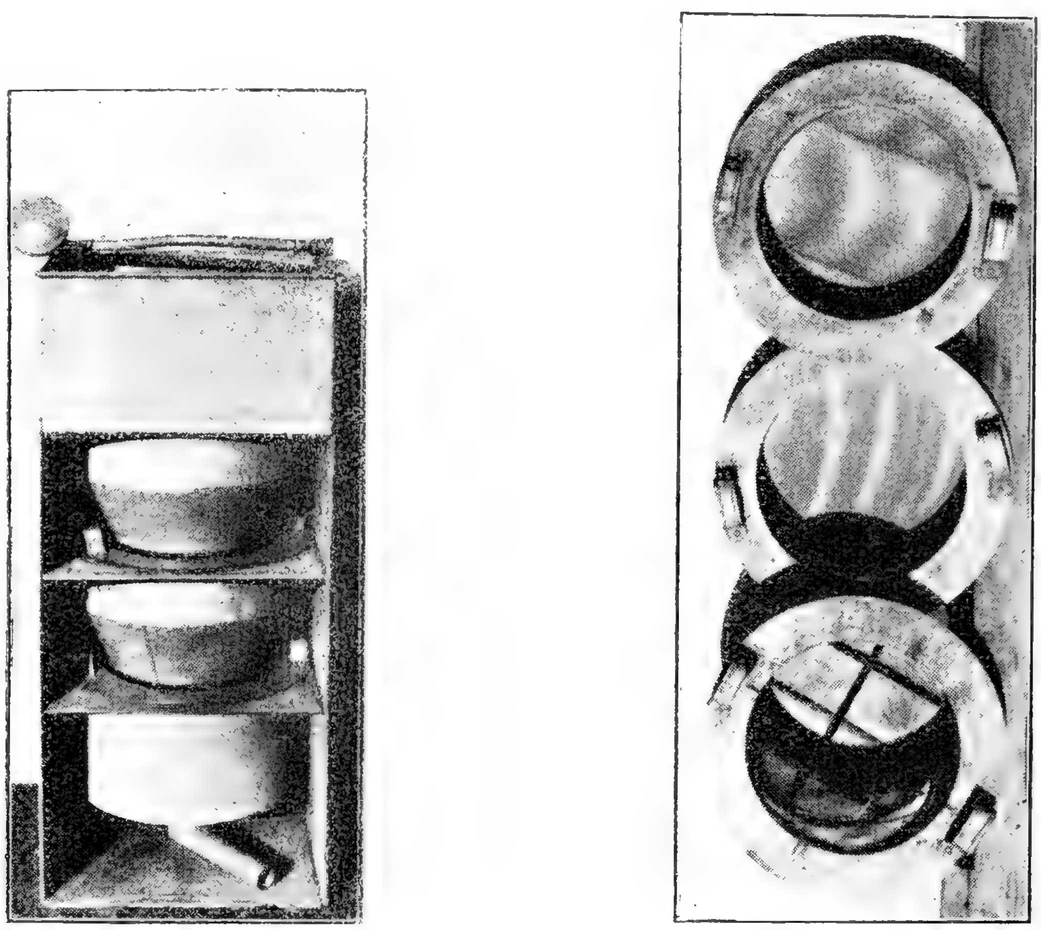


Fig. 2.

A similar periodic series of samples is taken in each other situation under study. A minimum interval of two weeks between samples has been found suitable during the period of greatest animal activity, which interval is increased, for greatest efficiency of effort, up to some three weeks during the semi-dormant period of spring and fall. A minimum of fourteen samples per year in each situation, during the 7½ months at Saskatoon when the soil is not completely frost-bound, has been bound satisfactory.

Results. — Four types of values, pertinent to the present discussion, have been found to result from the general work. First, there have appeared marked correlations between meteorological factors and the population trends of many species and larger taxonomic groups. There has been a significant bearing upon general agricultural practices and cultural measures for insect control. A third value has been the information, often unexpected, gained with respect to pests not directly under study or on species later arising to economic importance. The fourth significant result, closely connected with the other three, lies in the many definite leads secured for

detailed experiments in laboratory and field. The first two of these are amplified below.

Climatic Relations. — The results in bringing out climatic relations have been discussed at some length on another occasion, so will merely be summarized here. The continuously periodic nature and long duration of the quantitative work permits the graphic representation of populaton trends, not only of each abundant species but also of many larger taxonomic groups. The simultaneous work in several diverse situations minimizes the effect of local influences in any situation upon these general curves. The effects of any material weather variation from the normal may therefore be clearly depicted.

The most extensive correlations so far secured have been with precipitation, as is natural, both because of the known importance of rainfall as a limiting factor in prairie regions and as a result of good fortune in that the first two summers of the work were respectively the wettest and the driest on record at Saskatoon. The tentative conclusions drawn have been confirmed in two ways, by contrast between wetter and drier native communities, and by comparison with data from a few similar studies in moister climates. There have been, also, a number of definite observations with respect to the effect of temperature conditions, particularly as to rate of mortality during hibernation.

Perhaps of primary interest in the correlations is the evidence that several large taxonomic groups, — families, orders, classes or even phyla — react as more or less homogeneous ecological units with respect to certain major environmental influences, the members of such a group differing only in magnitude of response, not in its direction. Other groups, of course, for example the cutworm family, are of very diverse ecological requirements, genera and even species reacting in contrasting or opposing fashion. The standing of the general population at any time is a resultant of the diverse trends of its constituent groups in response to preceding and existing conditions.

The direction and magnitude of the response by the different groups is brought out most clearly when the stimulus is both intense and of long duration, as for example, a season very dry throughout. On the other hand, the observed trends in seasons with shorter wet or dry periods coming at various times, delimit the most critical periods for species or small groups. With a given species, its reaction to some factor variation may be exhibited as a change in the area infested, or as a change in numbers in the original area, or in both ways.

Another interesting aspect is the speed of reaction in relation to the type of life-history. The Hemiptera, for example, having for the most part more than one generation per year, show an almost immediately discernible response to factor variations of critical intensity. On the other hand, with the soil Diptera, most of which have but one generation per year at Saskatoon, the variations in the population curve show a considerable lag behind the factor changes which cause them. This lag is very pronounced in the case of the wireworms, with their long life cycle and slow development; for example, it is indicated that the full effect of the very dry season of 1924 was not shown in this curve until the end of 1925, possibly even later.

As the work progresses, it is becoming increasingly possible to analyze the population responses of a given species to weather fluctuations in terms of the more direct factors operating, such as direct effects of soil moisture and the like, effects on its food supply, influence on its natural enemies and competitors, these being often of a differential character.

The great importance, both immediate and potential to economic entomology, of these aspects is evident in part. It is significant that the generalizations tentatively drawn interpret and extend those occasional statements which have appeared in the literature relative to a few of the important insect pests of the region. The results which have been secured strongly indicate that accurate and sweeping conclusions of far-reaching usefulness will become possible through the work of other investigators, when the results from similar work in a large number of localities and regions shall become available for comparison.

Bearing on Agricultural Practices. — The carrying on of work simultaneously in cultivated fields and in native communities is of value, among other reasons, in that it permits an analysis of the distinctive conditions obtaining under cultivation. The dominating influence of arable land, taken as a whole, is the periodic cultivation and over-turning of the upper layer of soil, usually combined with a succession of different crops. The consequence is an instability of environment, and the periodic occurrence of drastic conditions.

The occurrence of a fauna characteristic of arable land is clearly indicated, as there is recognized to be a flora typical of it. Upon analysis it is found that both fauna and flora possess essentially the same characteristics. In brief these are: possession of adequate powers of resistance in some stage of development, of relatively great powers of multiplication and dispersal, or of a combination of the two. By means of the first, unfavourable periods can be endured, while the latter powers enable them rapidly to re-infest, from foci of infection, areas from which they have been driven by previous extreme conditions.

It is obvious that a species which is a serious pest year in and year out, possesses these characteristics in a greater degree than its natural enemies, at least with respect to the existing system of cultivation and crop sequence.

These considerations, it need scarcely be said, have a direct bearing in economic entomology upon the recommendations for crop rotations and specific modifications of farm practice for insect control, upon the advisability of soil fumigation or other general methods of animal destruction, and upon the usefulness under different circumstances of parasite introduction or dissemination.

Throughout the history of economic entomology whenever an insect problem of field and garden crop proved baffling, the stock recommendations have been "crop rotation" and "fall ploughing". The line of reasoning seems to have been that, as these were generally considered sound agricultural practices anyway, to recommend their employment would do no harm and might do some good. Let it be said at one that in several specific instances definite observations or even experiments have been the basis for the recommendations. Others, however, admittedly have been founded on pure theory or nothing at all.

With the further development of economic entomology, it seems that at least an attempt must be made to measure accurately, first, the net results of any control measure in biological terms. The method of general population studies already offers much promise as a means for final testing of many kinds of control measures. This work makes evident that changes in crop rotations or other farm practices, designed for insect pest control, should have a differential effect, — a selective action, — as between the major pest or pests and their natural enemies, injuring the former to the maximum extent, the latter to the minimum.

General methods of the destruction, such as soil fumigation, it is clear, must be utilized with even greater care, and, wherever possible, only after definitely knowing their eventual effect both upon invertebrates and micro-organisms. Otherwise there is a strong probability that the final net result may be the elimination even of the partial check previously exercised on a pest by its natural enemies, necessitating the constant repetition of the treatment.

Supplementary Population Studies.

The general population studies also serve a very important purpose as a standard for comparison, to permit extension of the results by means of less detailed sampling methods, specially designed with relation to some important pest which is under investigation. In this fashion, the immediate economic bearing can be greatly augmented with a relatively small additional expenditure of time and effort. The supplementary samples are designed to give a broader and more exact measure of the occurrence and fluctuations of the pest in question during important periods of its development. To conserve time, each sample of this type is made only detailed enough to show the numbers of the pest and of its known enemies and competitors, without exact reference to the total population.*)

Cutworm Problem. — Turning to the problem of cutworm control in general, it is seen that the chief, almost the sole, reliance is placed on poisoned baits. For the majority of cutworms under garden and truck crop conditions poisoned baits do afford a reasonably efficient and practical control.

With field crops, having a low unit value and of necessity a relatively slight amount of personal attention, the case is quite different, especially with grain crops and large scale farming. There control measures should be readily applicable over large areas, should be invariably effective and should not call for much labour or expense. In one or all of these respects poisoned bait is likely to fail under many circumstances. A few species, such as the pale western cutworm, have never been controlled by bait, while with many other soils cutworms, the bait method is only partly effective under conditions of dry soil, when some measure of control is most needed. Large scale distribution, evenly, cheaply and quickly, is still very much of a problem. There is also the difficulty which farmers experience of finding these rather inconspicuous pests in field crops in time

---

*) King and Atkinson, in Journ. of Economic Ent. 20, December 1927, and Annals of the Entomological Society of America XXI, June 1928, *re* quantitative work with cutworms.

to prevent their ravages, and, later, of convincing themselves of the effectiveness of the bait. It is evident that much careful work must be done with respect to poisoned baits for cutworms.

In realization of these limitations of baits, much attention is being given by entomologists to the possibility of effective control of cutworms by slight modifications of cultural methods. An instance of successful effort in this direction is the work of Seamans and others, as a result of which infestation of fallow fields by the destructive pale western cutworm *(Porosagrotis orthogonia* Morr.) can be avoided.

With either poisoned bait or cultural control measures for cutworms in field crops, however, the key to most effective control lies in finding some practical means of forecasting outbreaks with respect to general districts, particular localities, and fields of different types of cultivation. In quantitative methods lies the chief promise in much of cutworm investigation, especially in the above connection. Anticipation of future development must be based upon careful records and accurate knowledge of past fluctuations of infestation, and of the status of natural control factors. In the past, general statements of the amount of damage to crops have been almost the sole measure of the abundance of cutworms. With a few species, for which the physical conditions during a single critical period are of transcendent importance, or for which there is a close correlation between abundance and damage, even such records have served as a basis for forecasting methods of considerable practical usefulness. Noteworthy examples are found in the work of Seamans and Cook with the pale western cutworm and of Seamans with the army cutworm *(Chorizagrotis auxiliaris* Grote).

It has been established, however, that the amount of damage which occurs bears no direct or constant relation to the degree of infestation in the instance of the red-backed cutworm *(Euxoa ochrogaster* Gn.), which in this respect is deemed to be more or less representative of many other species. For example, it is estimated that the net cutworm damage to grain crops in the Saskatoon district in 1924 was very nearly equal to that of 1926, although the initial infestation was nearly six times as great in the latter years as in the former. To state it in another way, the potential destructiveness of each young cutworm was six times as great in 1924 as in 1926. The first clue to the explanation of this important fact was obtained in a quantitative examination relative to the much greater damage normally encountered on knolls. It was found that this difference occurred in spite of equality of infestation of the lower areas, where soil and vegetation conditions at time of egg laying had been similar. Further work established the fact that drier, warmer soil produces a marked differential effect, increasing cutworm activity and speed of development, changing its level of feeding to a more dangerous one, lessening the immediate effectiveness of disease, and decreasing plant resistance and powers of recovery.

Wireworm Problem. — With respect to the obscure and involved wireworm problem, population studies hold out even greater promise. In view of the fact that this important problem has received consideration since the earliest days of economic entomology and that, admittedly, the progress has been discouragingly slow, it is clear that

empirical methods must be reduced to a minimum. Wireworm censuses afford an important avenue of approach to a number of fundamental considerations and bring out points which can be further studied by definite laboratory and field experiments.

In the work at Saskatoon, little real progress was made towards practical control, until certain fundamental points began to be clarified, incidental to an examination of the data accumulating in the general population investigations. The initial confusion was due to a failure at first to distinguish between actual changes of infestation and mere differences in crop damage, a distinction which, it is now established, is a very real and important one with respect to the wireworm problem, especially of Western Canada.

In a recent detailed appraisal of the economic wireworm situation in Saskatchewan *) the following features were noted: — First, the occurrence of the most severe damage by wireworms, almost invariably to the first crop following summer-fallow; second, association of the heavier wireworm infestations, on the whole with fields cultivated continuously for many years; third, the long duration, under most conditions, of serious infestations when once established. The length of life cycle of the principal species is at least from 3 to 5 years under natural conditions. The quantitative field work has now shown that changes of infestation of this species normally take place very slowly and gradually. Only under unusually extreme weather or cultural conditions have sharp fluctuations of population been demonstrated.

It has been conclusively established that, without material changes in the number of wireworms in a field, net injury to the same kind of crop may be as much as 10 to 20 times as great in one year as in another, with much greater differences if different crops are considered. Among the causes of these large variations are soil and weather factors, particularly those affecting soil moisture conditions of the early growing season, as controlling the depth at which wireworm feeding occurs and the length of the period of feeding. A very appreciable amount of this variation of damage, on the other hand, has been found to result from conditions or factors which are subject to material control by human agency. For example, it has been proved that wireworm injury to wheat in drill rows thoroughly packed immediately after seeding, may be as low as one-firth to one-eighth that in similar unpacked rows, where soil and weather conditions are conducive to a maximum of wireworm activity. Cross-packing is, then, the first line of attack in lessening damage, but other cultural practices, such as depth of seeding and date of seeding, also have an important influence. As in previous work, no specific seed treatment of value has been found, but the quantitative work is the basis for a strong recommendation that the smut prevention treatment, for all seed wheat used in wireworm infested fields, be by the copper carbonate rather than the formalin method. More recently the work is beginning to bring out some important inter-relationships between soil fertility, or the presence of certain root diseases, and the damage potentialities of wireworms. This knowledge, it is deemed, will also in part be possible of utilization in control.

---

*) Scientific Agric. VIII. pp. 639—706, 1928.

It will again be observed that all of these factors affecting wireworm damage, — both the uncontrollable conditions, and the influences which are being utilized in practical cultural methods of control, — produce a differential effect as between the wheat plant and the wireworm. The rapidity and sturdiness of plant growth, determining the duration of exposure to vital injury and the powers of recovery of partly damaged plants, are materially affected, whilst at the same time the duration, extent and level of wireworm feeding and their rapidity of movement through the soil, may be greatly changed.

It would not be contained for a moment that these cultural methods to lessen wireworm injury are new discoveries. All of them, with many others, have been suggested in the literature, although usually rather half-heartedly and apparently seldom with any real confidence in their material value. The particular contribution here of quantitative methods lies in giving this needed confidence, in showing the extent to which each practice effects control and under what conditions, and in eliminating useless or economically impractical measures.

This confidence, in turn, makes it feasible to approach without undue haste or premature publication the second part of the problem, that of actually reducing the wireworm population in severely infested fields and of keeping it down in others where they are as yet less numerous. The quantitative methods appear invaluable in studying this phase, making possible an actual measure, firstly, of the results being secured by methods promising in theory, and later of the degree of practicability of measures found effective.

Conclusion.

In the entire preceding discussion, the emphasis intended has been, not upon the instances cited, but upon the principles and the potentialities which they serve to illustrate. In conclusion, therefore, a concept of the established or probable usefulness to field crop entomology of quantitative field methods may be summarized.

In line with the trends in soil science and in ecology, there is an increasing realization of the complexity of the problems, a recognition of the virtual impossibility of exact synthesis of natural conditions in such a way as to permit laboratory experimentation by the method of single factor variation, and of the necessity for careful field investigation by methods as exact as can be devised, the significance of the results to be clarified by statistical treatment.

Population studies afford the most accurate known means of investigating the complexes as they exist in the field. The present methods are still somewhat crude, especially where trees or tall shrubs are involved, but should be possible in time of almost any degree of refinement. The population studies are equally applicable to what may be termed quantitative observation of existing or natural conditions and to the exact measurement of the actual results being secured in field experiments. The quantitative work continuously gives important leads for laboratory and field experiments, the results from which, in turn, assist greatly in the interpretation of the complex data secured in the animal census work.

Possibly the greatest single contribution of general population studies is their influence on the point of view. Instead of thinking merely in terms of the effect on a single pest species, of temperature and moisture factors for example, there is considered their differential effect, as between the pest and its host plant, its natural enemies, and its competitors. Instead of studying as an unit one parasite species, however important, there is kept in view the *interrelations* between all the natural control factors, the influences limiting their usefulness, and their net combined effect on the host. The *selective* and *general* action of a control method is considered, not alone its obvious and immediate effect on the pest which happens for the moment to be of chief importance or the subject of study.

The eventual objective of any investigation of economic entomology is, of course, to remove or minimize the check on crop production which is exercised by the pest in question. General ecological work makes evident, however, that in the initial stages of an investigation, this final objective must be kept definitely in the background, so that the attention may be concentrated on the insect itself, not on the yield, — on the infestation, not on the damage. It shows that the surest and quickest route to lasting, practical control is by attaining as complete a knowledge as possible about all phases of the life of the pest in question and its relation to its entire environment.

Specifically, the following important economic objectives are attainable in a marked degree by population studies: — First, to find the actual amount of damage done by a pest, as determining to what extent control must proceed and expenditure can be made; secondly, to discover and measure the differential effect of various environmental factors, as between plant host and insect pest, a point of much practical importance since the rate of damage with equal infestation has been found to vary markedly with cultural, weather, soil, physiological and other variations; thirdly, to follow accurately the changes of infestation, both the very local and the more general, and to deduce some of the causes operating; fourthly, to determine the net effectiveness of natural control factors in general, the relative standing of the more important factors both physical and biological, their interrelations and the conditions limiting each; and fifthly, to use the above facts to secure practical control, either indirectly by lessening the infestation or directly by preventing the damage, or by combination of the two. In field crops, this result will be effected usually by means of comparatively slight but s e l e c t i v e changes in cultural practices, which must be correlated with the general agricultural procedure in each community.

The feasibility of accurately measuring both the net effectiveness and the degree of practicability of any measures designed for insect pest control, eliminates at once the advisability and the sometime-necessity for making recommendations on purely theoretical or observational grounds. This applies particularly to the more sweeping recommendations.

Quantitative field methods usually involve a mass of detailed and often very tedious work, much of which may not be illuminating until several months' or even years' results have been accumulated. Apparently, however, the methods have never failed in any line or scientific endeavour

to produce results fully commensurate with the efforts expended, if combined with powers of observation and ability to grasp significant points. Although comparatively a new development in economic entomology, instances of important practical accomplishment could be cited in several diverse divisions of this science.

All of these reasons, the evidently great potentialities for the future even more than the results already secured, not only justify but demand the wider adoption of population study methods, in some degree, by the larger experimental agencies. This is especially true relative to field crop and other large scale entomological problems which at present are approachable little, if at all, by ordinary methods of spraying and dusting. Wherever possible, these investigations should include general census work in at least one native community and in a cultivated field of some standard type, — such as spring wheat repeated each year, — together with similar study of the leading crops of the particular locality and supplementary samples relative to specific major pests.

Mosquitoes in China and their potential Relationship to Human Disease.*)

Professor Ernest Carroll Faust, M. A., Ph. D., Laboratory of Parasitolog.
Tulane University, New Orleans.

(With one map.)

Introduction.

The first demonstration of a mosquito in the rôle of a transmitter of disease was made by Manson in Amoy (1878), when he was able to show proof that the larvae of *Wuchereria bancrofti* not only underwent development in the mosquito *(Culex fatigans)*, but escaped as mature larvae from the proboscis of this host. This basic principle has been successively applied to malaria, yellow fever and dengue, and yet fifty years after Manson's epochal discovery the actual facts concerning mosquitoes in relation to human disease in China are indeed meager. Most physicians in China have been too busy in practising curative medicine to see the larger needs for investigations looking towards the prevention of disease. Those Westerners resident in China whom I have attempted to interest in malaria-investigation have for the most part considered that all the facts about mosquitoes in relationship to this disease were long since known, and that nothing remained to be done in China but to apply these data. But the size of the country and the common belief that all mosquitoes bred in the rice fields have so appalled these individuals that they have considered the task an impossible or an impracticable one. Little have any of them realized that in China, as in all other countries, the facts must be discovered *de novo* in their own peculiar setting, and none have had the courage or incentive to take up the work where Manson left off, or even to lend support to such a project. About all that has actually been done has been the collection of fairly representative samplings of mosquitoes along the coast of China and in a few inland cities. Most of these specimens have been identified by recognized Western dipterologists, whose reports have indicated their unquestionable interest in the mosquitoes of the region, but have all too plainly shown that the collections were very inadequate for so extensive an area.

Without a claim to any special knowledge of mosquitoes, but as a student of the distribution of parasitic diseases in China, I hope to be able to present briefly the few recorded facts regarding mosquitoes and disease in this extensive area, in order that the present status of the problem may be visualized.

---

*) Contribution from the Parasitology Laboratory, Department of Tropical Medicine, Tulane University of Louisiana.

Malaria.

Although malaria is not the scourge in China which it is in parts of Malaya or French Indo-China, it is responsible for a large proportion of the morbidity and no small amount of the mortality in the country. This is particularly true in the southern portion of the area, lying between the 20th and 25th degrees of North latitude. However, the broad belt between 25^0 and 35^0 N. latitude is one in which malignant subtertian malaria is also present, while endemic tertian malaria in China has been found in several localities even north of the 40th parallel.

The concentration of the heavy areas of infection in China along the south coast, in the adjacent region of Formosa and in the Central and Lower Yangtze Valley is for the most part dependent on favorable amounts of moisture and temperature. South of the 25th parallel moisture is sufficient and the temperature warm enough for the breeding of *Anopheles* and the incubation of the malarial plasmodia in the anopheline hosts throughout he year. While the moisture in Central China is undoubtedly adequate during the entire twelve months, the temperature frequently approaches the freezing point, with the result that the winter-breeding season is materially prolonged and the infectivity of the appropriate malarial mosquitoes correspondingly reduced. In the northern belt the yearly precipitation drops rapidly from 75 cm. in the Huai River valley to 50 cm. in and around Peking and to 25 cm. on the Shansi plain. Coupled with this condition is the short duration of the moist season which lasts only about two months of the summer (the middle of June to the middle of August) in the northern region, which condition, together with the extreme dry cold of the winter season, limits breeding to a few summer months. The result is that aestivo-autumnal and quartan malaria have not been able to establish themselves as far north as Peking, although they have both been introduced from time to time into this region; and that tertian malaria, although endemic in a mild way on the Peking plain, has not become established on the more elevated and arid Shansi plain to the west.

The distribution of anopheline mosquitoes in China is of more than ordinary interest, since an opportunity is offered to study a gradation from strictly Oriental types in the South to strictly Palearctic ones in the North. In the Southernmost belt, which lies south of 25^0 North latitude and which may be defined as the Northern range for strictly Oriental forms, from seven to eight species of *Anopheles* have been reported on the mainland and as many as fourteen species on Formosa. While the largest number in this zone is smaller than that for French Indo-China, and while certain species, such as *Anopheles barbirostris, A. fuliginosus, A. jamesi, A. kochi, A. aitkeni, A. vagus* and *A. leucosphyra,* which occur in Saigon, do not reach as far North in China proper as Hongkong, certain typical Oriental species, among which are *A. maculatus, A. maculipalpis* and *A. minimus,* are commonly distributed throughout the zone, while *A. barbirostris, A. subpictus, A. ludlowi, A. tessalatus* and *A. fuliginosus* are among the representatives of the tropical species in Formosa. *A. hyrcanus* var. *sinensis* is common throughout this entire zone.

In the next region to the North, which extends roughly from the 25th to the 35th parallel North latitude, and which includes the middle

third of China, only *Anopheles hyrcanus* has been reported. From the 35th to the 40th parallels North latitude three species have been found on the mainland, while other forms have been described for Korea and Japan. The most prevalent species throughout this belt is *Anopheles hyrcanus.* From two regions in North China a new species, *A. pattoni,* has recently been described (Christophers, 1926). In the hills to the west of Peking, as well as from the mountain districts of Japan and Formosa, the species *A. lindesayi* is occasionally found. *A. punctibasis (A. koreicus* Yamada) occurs in Korea and Japan, while in the latter country *A. hyrcanus* var. *sineroides* (Yamada) and *A. gigas* have been taken. *(A. gigas* has also been reported from Chungking, far up the Yangtze Valley.)

With the exception of Northern Japan the belt stretching to the North of 40° N. latitude contains only one known malarial mosquito, *A. maculipennis.* This latter region is practically outside of China proper, but includes Mongolia, parts of Manchuria and the Maritime provinces of Siberia.

In considering the anopheline species in China and adjacent areas in their relationship to the transmission of malaria within this territory there are very few facts to be presented. No experimental work in China proper has been published indicating which species are responsible for one or more of the three types of malarial infection in a given endemic area. Nor have attempts been made to dissect mosquitoes to determine their natural *Plusmodium*-index. On the other hand, studies in Japan in at least two separate areas have shown that *A. hyrcanus* is the natural definitive host of *Plasmodium vivax,* while Japanese investigators in Formosa have found this same species naturally infested with all three malarial plasmodia. They have also found *A. (Pyretophorus) minimus* naturally infected with *Laverania malariae* and have experimentally infected *A. (Myzomyia) subpictus* and *A. (Myzomyia) tessalatus* with this species of parasite.

In the absence of actual incriminating proof the propinquity to human dwellings in malarious regions of China, of species of *Anopheles* which have been incriminated in malaria transmission in adjacent areas, constitutes more or less definite circumstantial evidence of the willingness of these forms to take human blood, and furnishes indirect evidence of their probable rôle as malarial carriers in China. The one species which is ubiquitous throughout the area is *Anopheles hyrcanus.* It is the most common anopheline even in South China where other species are rather plentiful. It breeds in a variety of locations: in seepage pockets on the sides of hills; in protected pools in hill streams; in irrigation ditches in rice fields and actually in the paddy fields themselves wherever *Spirogyra* grows abundantly; in temporary overflow ponds and lakes amidst grass and weeds. In all cases the water is clear; usually it is moving. *Culex bitaeniorhynchus* and *C. tritaeniorhynchus* frequently occur in the same breeding places. For Central China this species of *Anopheles* is the only one known to occur. In this region it may be considered as the almost certain transmitting agent for malaria. In the Northern belt it is much more common than *Myzomyia pattoni* which breeds in the same habitats, while *Anopheles lindesayi* is both so rare in occurrence and so remote from the usual human habitations that its host-relationship to endemic malaria in China is very unlikely. Until more is known about *A. pattoni* it is impossible to exclude it from responsibility, but it seems highly probable that *A. hyrcanus* is the normal

primary source of infection throughout Central and North China. In South China it is much more difficult to fix responsibility. Certainly in some areas, as in Hongkong, Canton and Swatow, *Nyssorhynchus maculatus* must be seriously considered and to a lesser extent also *Nyssorhynchus maculipalpis* and *Pyretophorus minimus*. However, of all the forms reported, *A. hyrcanus* is the most frequent around human dwellings, and in the writer's experience the most hungry for blood of the Anophelines in South China. It remains to be actually demonstrated whether this circumstantial incrimination of *A. hyrcanus* through China wherever malaria is prevalent is justified and, likewise, whether *Nyssorhynchus maculatus* and other strictly Oriental species are important carriers in China south of the 25th parallel as they are in Malaya and French Indo-China. Definite conclusions must be reserved until such proof is forthcoming.

The presence of endemic tertian malaria, (1), in the Ordos of North Shansi, north of the northernmost bend of the Yellow River, (2), along the Black Dragon River in Manchuria and, (3) in the vicinity of Vladivostock, where only *A. maculipennis* is known, apparently involves this mosquito, but here, again, actual proof is lacking. Thus the entire problem of anopheline transmission of malaria in China is one in which only the most superficial beginning toward a solution has been made. Experience in other countries has demonstrated time and again that the habits of a particular anopheline mosquito in one area are not necessarily identical with those of the same species in an adjacent region, and that incrimination of such a species in the primary rôle of malaria-transmission in the first area does not necessarily constitute sound proof of similar involvement in the second. Intensive and extensive studies are required in representative parts of China to determine the biology of the anopheline mosquitoes found in these regions and their relative preference for human or other types of blood. Likewise, consideration must be given to the meteorological and other physical factors in selected zones in relation to the ability of mosquito breeding and malarial plasmodium-incubation within the mosquito host. Furthermore, the actual percentage of infection of this host in the respective areas must be determined. Until this is done on an extensive scale attempts to undertake anti-anopheline campaigns in China are bound to be futile.

Dengue.

Dengue has occurred in China and Formosa from time to time in epidemic form. In Hongkong it is also endemic to a certain extent. Authenticated outbreaks, which have temporarily disabled a large percentage of the population, have been reported from Hongkong, Amoy, Formosa and even as far North as Hangchow and Shanghai. Thusfar only one mosquito, *Aedes aegypti,* has been proved to transmit the virus of this disease. The present known distribution of *A. (Stegomyia) aegypti* extends northward along the border of the South China Sea only through Tonkin to Hongkong, Amoy and Formosa, but even in Hongkong it is relatively rare. From the Hainan Straits northward it tends to be replaced by *A. (Stegomyia) albopictus,* which is the most common species of the genus as far north as Northern Kiangsu Province and on the southern side of Japan. In Shantung the representative of this subgenus is *A. chemalpoensis.*

On the other hand, *Aedes (Ecculex) vexans* var. *nipponi* occurs throughout the entire Sino-Japanese area. The Oriental species *A. w-alba* has been recorded in the region only from Hongkong and Formosa. In the North *A. (Finlaya) koreicus* on the mainland, including both China and Korea, and *A. (Finlaya) togoi* and *A. (Finlaya) japonicus* in Japan are the representatives of their subgenus, while the species *togoi* has also been recovered from Hongkong. In the South *A. (Ochlerotatus) macfarlanei* has been taken from Canton and Hongkong; in the North it is replaced by the species *dorsalis.* The present data on the distribution of species of the genus *Aedes* in the Sino-Japanese areas, therefore, suggest that some species other than *A. aegypti* must be responsible for epidemics of Dengue that occur north of Hongkong, Amoy and Formosa. Possibly in past years *A. aegypti* had a more northerly distribution than it has at present, but there is no evidence in support of this hypothesis. The closest relative having a distribution comparable to that of the outbreaks of the disease is *A. albopictus.* Actual proof of the ability of this species to carry the disease is entirely lacking.

Yellow Fever.

Yellow fever is not known to have even been introduced along the China Coast. According to surveys made by Stanton (1920) in the equatorial region of Far Eastern ports and by Lamborn (1922) in the ports of China and Japan, the prevalence of *Aedes aegypti* all the year round in the more southerly region is not likely to cause the spread of yellow fever in the Far East, since the main route of traffic is from west to east and since the more northerly portion of the route which is first touched by vessels east-bound is too cold during the greater part of the year to allow this species of mosquito to breed. However, the recent interbreeding experiments of Brug (1928) between Cuban and Javanese representatives of *Aedes aegypti* leave no doubt that yellow fever, if once introduced into the more southerly belt, would find identical transmitting agents in this region which it has utilized in the Western Hemisphere.

Filariasis.

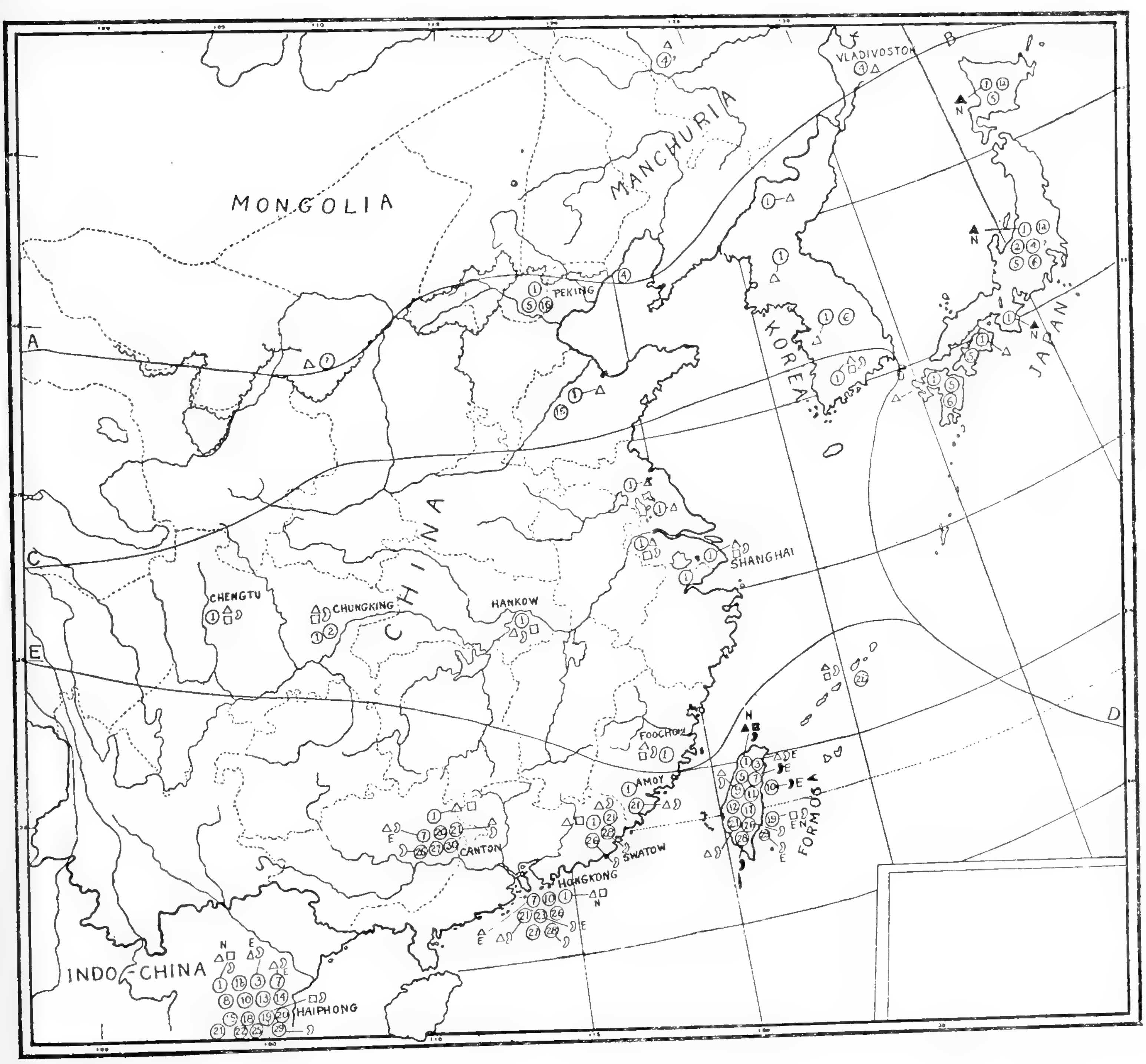
Filarial infection in the Sino-Japanese area is confined solely to the species *Wuchereria bancrofti.* Along the coast the infection is prevalent from Malaya, through French Indo-China and in China proper as far north as the southern part of Shantung Province. It also extends up the Yangtze River at least as far as Chungking and probably as far as the Chengtu plain. It occurs commonly in Formosa, the Loo Choo Islands, Southern Korea and Japan. However, it is not known to exist in the typical Palearctic portion of the region. The *Microfilaria* of Bancroft's Filaria observes a strict nocturnal periodicity in the area under consideration. It was in Amoy, Fukien Province, China, that Manson first observed this periodicity and by putting rational deduction to the test made the epochal discovery that a species of *Culex (C. fatigans)* served as the intermediate host of the organism in Amoy. Although scores of experiments have been conducted in other parts of the world where the infection is prevalent to determine the culicid host involved in the transmission of the infection, and

although many species of *Culicidae* have been found to be either appropriate or semiappropiate intermediate hosts, very few attempts have been made to continue in the Far East the work initiated by Manson. Chuitton (1925) found a *Culex* (stated by him to be *C. pipiens)* to be the vector of the infection in Indo-China. However, Dr. F. H. Guerin, of Saigon, has written me that *C. pipiens* has not been recorded from the region and that "the author did not give any characteristics of the species of mosquito which he utilized in his experiments; and that there is strong evidence that he had to do with *Culex fatigans*". More recently, however, Lee (1926) has definitely incriminated *C. pipiens* in Northern Kiangsu Province, just north of the range of *C. fatigans.* That *C. fatigans* is the primary intermediate host of the infection in the more southern part of the area, where this is the most common mosquito, seems a reasonable hypothesis. The presence of this species in Southern Korea and on the south side of Japan at least as far eastward as Kobe also serves to place it under suspicion in this territory. In China proper, however, from the Yangtze River northward and in Northern Korea and North-eastern Japan this more tropical species is replaced by *C. pipiens,* and the part of the northern territory in which filariasis is present most likely owes its infection to this temperate zone species. Thusfar there is no ground for suspicion that any of the several other species of *Culex,* such as *C. bitaeniorhynchus, C. concolor, C. fuscocephalus, C. mimeticus, C. sinensis, C. sitiens, C. tritaeniorhynchus, C. virgatipes* and *C. vishnui* in the more southerly portion, and *C. bitaeniorhynchus, C. tritaeniorhynchus, C. sinensis, C. hayashi, C. orientalis* and *C. vishnui* in the more northerly region of the infection, are involved in its transmission. Likewise, species of *Anopheles* and *Aedes* in the area have not been seriously considered as vectors. It is evident that a great deal of work on the culicid transmission of Bancroft's Filaria requires to be done before the epidemiology of the disease in China is on a sure foundation.

Conclusion.

The meager data which have been available for consultation and compilation regarding the species of mosquitoes in China and their relationship to disease are consistent in indicating quite definite limits of distribution of typically Oriental species on the one hand and of typically Palearctic species on the other, with a middle belt in which more adaptive cosmopolitan forms occur. Thus the northern limit of strictly Oriental species of *Anopheles* lies just north of the 25th parallel; and that of the Palearctic species, *Anopheles maculipennis,* extends south nearly as far as the 40th parallel; while *A. hyrcanus* is the predominant, member of this genus in the intermediate zone, although certain species which have not been reported either from the more northerly or southerly zones are found in this intermediate region. The endemicity of malignant subtertian malaria is recorded from China up to 35° North latitude and from Korea and Japan from a slightly more northern territory. Likewise the heavy incidence of *Wuchereria bancrofti* as far north as Southern Shantung Province where the tropical species, *Culex fatigans,* does not occur, indicates the adaptability of an atypical host-species of mosquitoes to a certain infection where

the environmental conditions were otherwise sufficiently favorable for the propagation of the infection. By and large it may be seen that intensive infection occurs only in the southern belt (south of 25°); that extensive infection occurs as far north as 35° North latitude; and that incidental infection may occur farther to the north. The northern limit of endemic malignant subtertian malaria and of filariasis in China proper (35° N. latitude) is essentially the 75 cm. precipitation line. Moreover, this same line of minimal moisture requirement marks the northern limit of clinical hookworm disease. It would, therefore, appear that moisture also plays an important indirect rôle in the propagation of such diseases. Thus temperature and moisture are probably the most essential factors in determining the limitation and spread of malaria and filariasis, while dengue and probably yellow fever, if once introduced, would be much more limited by temperature requirements. Other unknown factors may also be involved in each infection. On the whole China is still one of the least worked, yet most fruitful fields for investigation in faunistic parasitology.



Map showing the known distribution of Anopheline Mosquitoes and their known relationship to Malaria in the Sino-Japanese Areas.
Explanation on pp. 266,267.

Literature.

1. Brug, S. L., 1928. Remarks to the previous paper of Prof. Dr. W. H. Hoffmann; in Mededeelingen van den Dienst der Volksgezondheid in Ned.-Indie 17, p. 1.
2. Christophers, S. J., 1926. *Myzomyia pattoni* n. sp.; in Indian Journ. Med. Research, 13, pp. 871—879.
3. Chuitton, F. le, 1924. Recherches sur l'épidémiologie de la filariose *(Filaria bancrofti* Cobbold, 1877) en Cochinchine; in Bul. Soc. Path. Exot., 17, pp. 405—409.
4. Edwards, F. W. 1916. Mosquitoes of China collected by H. Macfarlane; in Bull. Entomol. Research, 6, pp. 67—68.
5. — 1912. A revision of the mosquitos of the Palearctic region; l. c., 12, pp. 263—351.
6. Faust, E. C., 1926. An inquiry into the prevalence of malaria in China; in China Med. Journ., 40, pp. 937—956.
7. Given, D. H. C., 1928. Health organization on H. M. naval base Singapore, and results: with comments on the practice of preventive medicine seen during tours in the Far East; in Trans. R. Soc. Trop. Med. Hyg., 21, pp. 346 — 362.
8. Koidzumi, M., 1925. The Anophelines of Formosa; in Japanese Journ. Zool., 37, pp. 314—377 (Japanese text with English summary).
9. — 1926. Eight years' observation of the seasonal prevalence of *Anopheles sinensis* W. in Formosa, with some remarks on the influence of climatic conditions and on the habits of the mosquitoes; in Journ. Med. Assn. Formosa. no. 256 (Japanese text with English summary).
10. Lamborn, W. A., 1922. The mosquitos of some ports of China and Japan; in Bull. Entomol. Research, 12, pp. 401—409.
11. Lee, C. U., 1926. Filariasis investigations in the Province of Kiang Su, China; in Trans. R. Soc. Trop. Med. Hyg., 20, pp. 279—287.
12. Manson, P., 1878. Further observations on *Filaria sanguinis hominis;* in Chinese Customs Med. Repts., Vol. 2, no. 14, pp. 1—26.
13. Meleney, H. E., Lee, C. U. and Chang, H. L., 1927. A preliminary survey of the anopheline mosquitoes of the Peking area; in China Med. Journ., 41, pp. 509—512.
14. Severn, A. G. M., 1925. The mosquitos of Hongkong; in The Caduceus (Hongkong), pp. 5—9.
15. Stanton, A. T. 1920. The mosquitos of Far Eastern ports with special reference to the prevalence of *Stegomyia fasciata.* F.; in Bul. Entomol. Research, 10, pp. 333—334.
16. Yamada, S., 1925. A revision of the adult anopheline mosquitoes of Japan: systematic descriptions, their habits and their relations to human diseases, together with an account of three new species; in Sci. Repts. Govt. Inst. Infect. Diseases (Tokyo), 3, pp. 215—141.

Legend key for the known distribution of Anopheline mosquitoes and their known relationship to Malaria in the Sino-Japanese areas (See Map).

1. *Anopheles (Anopheles) hyrcanus* var. *sinensis* Wied.

1a. *A. hyrcanus* var. *sineroides* Yamada.

1b. *A. hyrcanus* var. *nigerrimus* Giles.

2. A. gigas Giles (= *A. edwardsi* Yamada?).
3. *A. barbirostris* van d. Wulp.
4. *A. maculipennis* Meigen.
5. *A. lindesayi* Giles (= *A. plecau* Koidzumi).
6. *A. punctibasis* Edw. (= *A. koreicus* Yamada and Watanabe).
7. *A. (Myzomyia) subpictus* Theob. (= *A. rossi* Giles).
8. *A. albirostris* Theob.
9. *A. ludlowi* Theob. (= *A. hatorii* Koidzumi).
10. *A. tessalatus* Theob.
11. *A. thorntoni* Ludlow.
12. *A. listoni* Giles.
13. *A. christophersi* Theob.
14. *A. superpictus* Grassi.
15. *A. mastersi* Skuse.

16. *A. pattoni* Christophers.
17. *A. candidiensis* Koidzumi.
18. *A. (Nyssorhynchus) willmori* James (= *A. hanabusai* Yamada).
19. *A. fuliginosus* Giles.
20. *A. punctulatus* Theob.
21. *A. maculatus* Theob.
22. *A. stephensi* Liston.
23. *A. karwari* James.
24. *A. philippinensis* Ludlow.
25. *A. jamesi* Theob.
26. *A. maculipalpis* Giles (= *A. indiensis* Theob.; *A. splendidus* Koidz.).
27. *A. (Pyretophorus) jeyporensis* James.
28. *A. minimus* Theob. (= var. *fenestus?).*
29. *A. (Cellia) kochi* Dönitz.
30. *A. costalis* Loew.
31. *A. aitkeni* James.
32. *A. vagus* Dönitz.
33. *A. leucosphyra* Dönitz.

△ = tertian malaria, ▢ = quartan malaria, ☽ = aestivo-autumnal malaria. Solid symbols indicate local proof incriminating anopheline species in malarial transmission. N = natural infection, E = experimental infection.

A—B = probable southern limit of strictly Palearctic Anopheles.

C—D = northern limit of endemic malignant aestivo-autumnal malaria.

E—D = northern limit of strictly Oriental Anopheles.

Damage by Termites causes Modification of Building Codes.

Thos. E. Snyder, Senor Entomologist, Bureau of Entomology, U. S. Department of Agriculture, Washington, D. C.

(With 3 text-figures.)

Over 1,600 kinds of termites have been described from various parts of the world; this number includes the species, subspecies, varieties, forms, etc. The Arctic and Antarctic are the only regions not inhabited by termites. The largest number of species of termites occur in the Ethiopian region. Other great centers of distribution are the Neotropical, Oriental, Indomalayan and Australian zoogeographical regions. Smaller numbers of species occur in the more temperate Nearctic and Palaearctic regions.

In portions of most of these regions termites are widespread, occur in great numbers, are of extremely diverse kinds, and of widely different habits and habitats. Nevertheless, it is believed that by following proper methods in the construction of buildings the greater portion of damage by termites to the woodwork and contents thereof can be prevented or greatly curtailed.

Three Types of Termites.

The termites which damage buildings may be separated into three classes, namely: *non-subterranean termites,* which do not burrow in the ground, but attack the wood of buildings or trees directly; *subterranean termites,* which attack the wood of buildings, trees or living crops indirectly from burrows in the earth; and *mound or carton nest building termites,* which are also subterranean in habit.

A. Non-Subterranean or Dry-Wood Termites.

Non-subterranean or dry-wood termites do not burrow in the ground, but fly to and attack wood directly. Instead of following the grain of the wood continuously, they excavate longitudinal chambers of limited length through it. The sexual adults, after they have lost their wings, and the young or nymphs, are the destructive forms. Their pellets of excrement are regularly impressed, and sometimes completely fill or block up the burrows in a compact mass; they are often expelled as dry droppings from the infested wood and serve as a warning of infestation. These termites are destructive to the woodwork and furniture in buildings, as well as to living trees. Dry-wood termites can exist without the great amount of moisture necessary to the life of termites which are subterranean in habit, and can live in wood containing less than the 12% to 15% of moisture normally contained in air dried wood.

Fumigation. — Fumigation with the very poisonous hydrocyanic-acid gas will kill dry-wood termites infesting the woodwork of buildings and boats. This gas is *very dangerous*, and fumigation with it should be done only by an expert *). The infested wood should be exposed as much as possible and, in order to render fumigation fully efficient, it may be necessary to open up some of the structure.

Where several stories of a building are infested, the windows should be sealed and, after the fumigation is completed, the rooms should be aired by opening windows by means of cords, from the outside. The usual proportions of chemicals should be employed; that is, 1 ounce (avoirdupois) of sodium cyanide to 1½ fluid ounces of sulphuric acid and 3 fluid ounces of water; but 12 ounces of the cyanide per 1,000 cubic feet of room capacity should be used instead of the 10 ounces usually recommended, thus making the gas 20 per cent stronger. This fumigation under favorable conditions will result in the death of the insects within the wood. Fumigation should be done just before the winged adults are ready to fly. At that time the winged insects are present in the outer layers of the wood where they are readily reached by the gas, and the fumigation will destroy large numbers of them. Their presence near the surface may be determined by cutting into the wood, or may be detected by the flight of a few individuals.

Furniture infested by this type of termites is usually fumigated in steel cylinders with carbon disulphide gas, or given the more effective heat treatments.

Heat. — Temperatures of 130° F and over can be utilized in killing termites infesting the woodwork of railroad cars, furniture, etc. In Hawaii, a chamber of reinforced concrete, large enough to contain a passenger coach or two freight cars run in on rails was specially constructed. The sides of the interior of the chamber were equipped with coils of piping in which live steam from a locomotive was utilized, and at 90 pounds pressure it was possible to subject the infested wood to temperatures of 150° F, maintained for at least 1½ hours. The heat was applied and gradually raised while the temperature could be determined from a thermograph on the exterior of this building. The paint or varnish finish on the wood of the cars treated was not injured by the heat.

Such a chamber should be located at all ports where wood infested by dry-wood termites or other borers is liable to be brought in, and the infested wood subjected to a heat treatment, which is more reliable than fumigation.

Insecticides or Poisons. — Poisons can be used to kill non-subterranean termites within the wood. Insecticides useful for this purpose are orthodichlorobenzene, or a 10% solution kerosene emulsion, or a miscible oil poisoned by dissolving 1 ounce of sodium arsenite in each gallon of water used for diluting the stock mixture. The infested wood is drenched with the insecticide by swabbing with a saturated rag or mop; several treatments may be necessary, and careful watch should be maintained until it is certain that all the termites are dead.

---

*) 1916. Howard, L. O., and Popenoe, C. H., Hydrocyanic-Acid Gas against Household Insects; in Farmers' Bul. 699, U. S. Dept. Agric., Washington, D. C.

In Hawaii, dry Paris green blown into galleries in infested wood with a bellows has been used successfully by Dr. Ehrhorn. If moisture is present, this powder will cake and become ineffective, hence several applications may be necessary.

Impregnation with Wood Preservatives. — In regions where much damage is caused by dry-wood termites, all woodwork used in buildings should be impregnated with a standard chemical wood preservative to prevent attack *). This impregnation is made before the wood is placed in the structure and should be given to the wood after it has been cut to exact necessary dimensions. In case the impregnated wood is to be framed after treatment, the cut surfaces should be given a brush or dipping treatment with the hot chemical. Such impregnated wood or timber can be purchased at retail lumber yards in various sections of the United States.

For interior woodwork and furniture an impregnation giving an average absorption of from ¾ to 1½ pounds of dry zinc chloride salt per cubic foot is recommended. Sodium fluoride and chlorinated naphthalene, though more expensive, are also effective preservatives for timber that is not to be used in contact with the ground, where moisture would cause leaching. These chemicals could be adapted to special, but more limited uses.

Wood-pulp or fiber products, such as the various wood-fiber processed or composition boards, or cane-fiber boards, for interior finish and substitutes for lath, or for exterior use, can be protected from attack by termites by adding certain poisons, such as crude carbolic acid, to the pulp or laminated boards in the course of manufacture. Available poisons for this purpose are crude carbolic acid, used at the rate of 1 gallon to 1,000 square feet; bichloride of mercury at the rate of 49 ounces per 1,000 square feet; and copper sulphate, at the rate of 113 ounces per 1,000 square feet. Sodium fluoride, sodium fluosilicate, sodium dinitrophenolate or chlorinated naphthalene are also effective poisons for protecting such products from attack by dry-wood termites. Experiments now being conducted may determine that other poisons more effective and cheaper are available.

B. Subterranean or Ground-Nesting Termites.

Subterranean termites normally live in wood in forests, in the treeless plains underneath the ground in the roots of vegetation, or in carton or mound nests. Since termites are soft-bodied they always remain hidden within wood, in the earth, or within nests or earth-like shelter tubes. The wingless, sterile workers are the wood-destroying forms. In burrowing in wood the grain is usually followed, and the softer wood eaten out.

By man's disturbance of the balance of nature in felling forests, clearing and cultivating land as well carrying on more extensive building operations, termites have become seriously destructive in many regions to buildings and cultivated trees and crops.

Indications of Infestation. — The annual emergence of large numbers of the flying termites is an indication as well as a warning that the wood-

*) 1924. Snyder, T. E. Tests of Methods of Protecting Woods against Termites or White Ants; in Bul. 1231, U. S. Dept. Agric., Wash., D. C.

work is infested by subterranean termites, and the point of emergence indicates the aproximate location of the infested timbers. Even if the insects are not observed "swarming", large numbers of the dead winged adults or of the discarded wings usually will be found nearby. Another warning is the presence of branching shelter tubes of small diameter, made of earth mixed with finely digested wood, on foundation timbers, or over the surface of stone, brick, or other impenetrable foundation material, through which the ground-nesting insects travel from the ground to the woodwork. These tubes should be broken off and the ground where they originate broken up and drenched with poison.

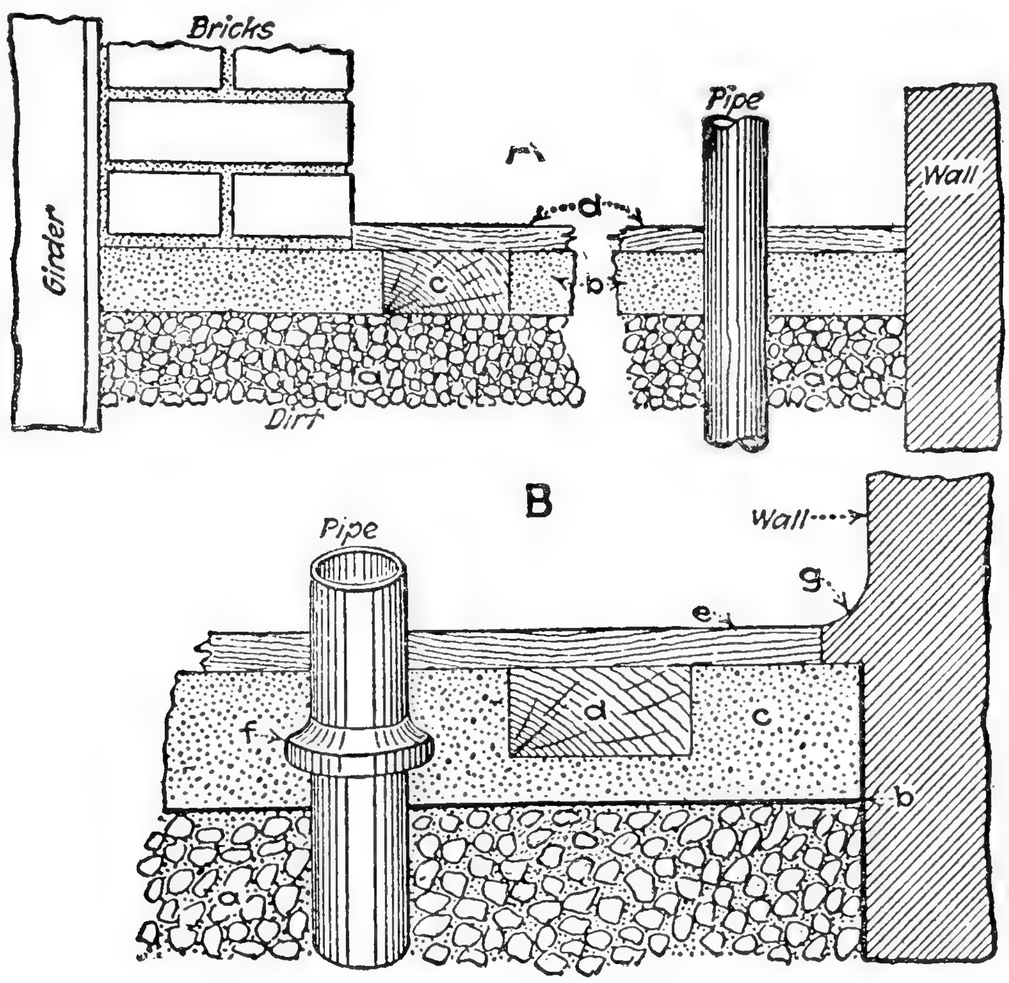


Fig. 1.

A, Improperly constructed concrete flooring: a, Gravel or cinders loosely cemented, with coarse contrete, 3 inches thick, but with many crevices and holes; b, solid, dense concrete, 2 inches thick; c, 2 by 4 inches untreated wood sleeper set in moist concrete over the grout; d, 7—8 inches pine flooring nailed to sleepers. **B**, Properly constructed concrete flooring: a, Gravel or cinders loosely cemented with coarse concrete, but with many crevices and holes; b, asphalt waterproofing 1—8 inches thick; c, dense concrete, 3 inches thick; d, 2 by 4 inches treated wood sleeper set in a groove in concrete which insulates it from termites in the earth; e, 7—8 inches flooring nailed on sleepers; f, metal collar around pipe which runs down through the concrete (this collar should be soldered to the pipe and embedded in the concrete); g, shoulder ot concrete at point of wall and concrete floor to avoid a right-angle connection and consequent cracking.

Destruction of Breeding Places about the Building Site. — If buildings are to be constructed on recently cleared woodland, decaying logs and stumps should be removed from the soil in the vicinity and burned; untreated wooden fence posts, sidewalks, etc., should also be removed. If subterranean termites are numerous in the earth, the soil should be deeply ploughed or otherwise broken up and treated with chemicals to kill the insects. Effective poisons for this purpose are calcium or sodium

cynaide *); a 10% solution of sodium arsenite; 1 part coal-tar creosote and 3 parts kerosene oil (this mixture should be strained through burlap before use); carbon-disulphide emulsion, which is on the market ready for use; orthodichlorobenzene; or other contact poisons or gases. In using any of them the soil should be thoroughly saturated. Live steam forced into the soil will serve the same purpose as the gases. The land can also be temporarily flooded to kill termites in the soil, if flooding is practicable.

The presence of termites can be detected by planting pine or fir trap stakes in the soil. If these are attacked, carbon disulphide **) should be poured into the stake hole, protected by a layer of paper and then covered with dirt. Care should be taken in handling this volatile fluid, as the gas or vapor from it is highly inflammable, and explosive when mixed with air in certain proportions; no flame should be brought near it, and the fumes should not be inhaled, as they are poisonous.

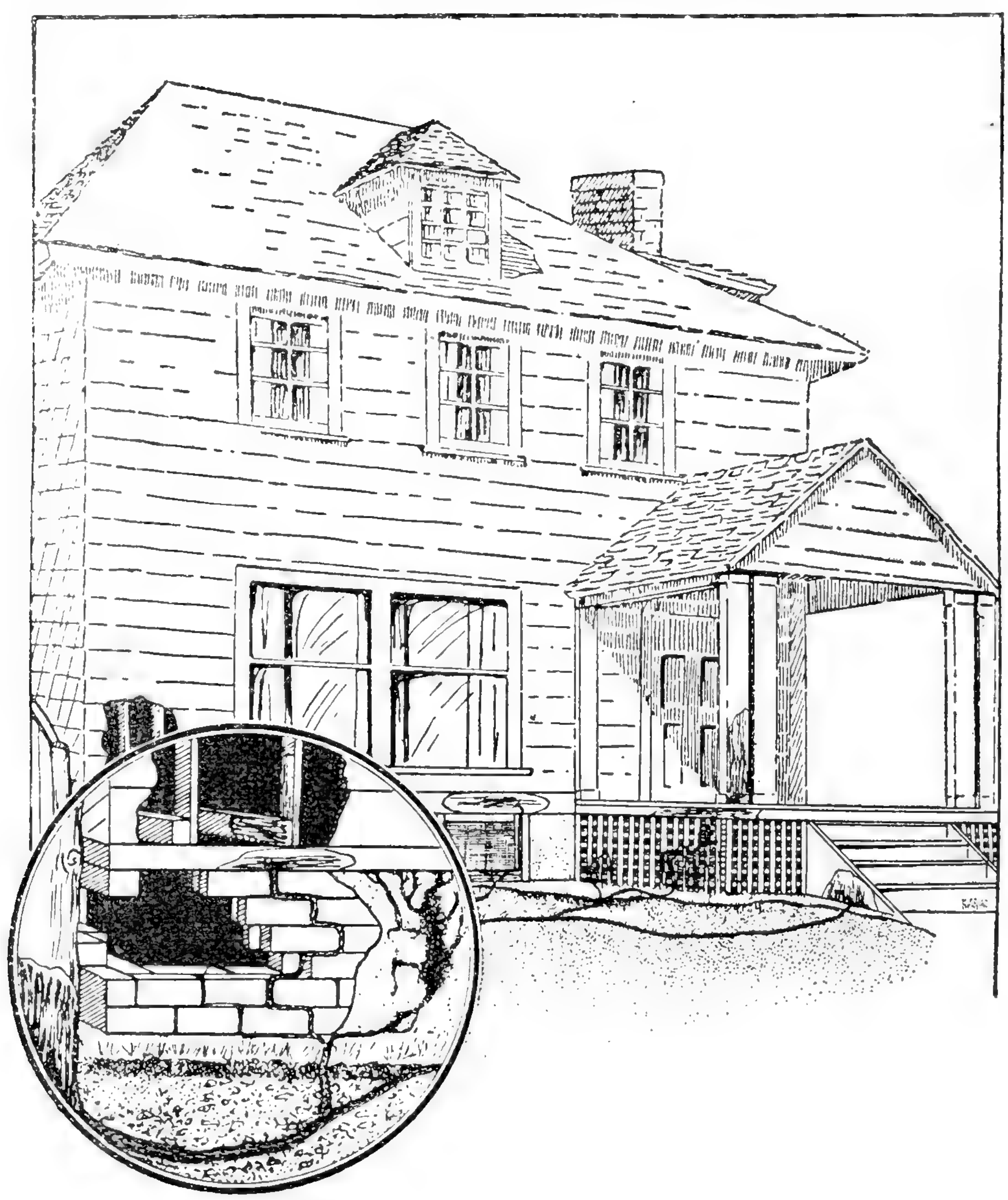


Fig. 2.

View of frame house to show how subterranean termites gain entrance to the building through: (1) untreated wood in contact with the ground; (2) in earth-like shelter tubes constructed over stucco or concrete; (3) improper grades of mortar in foundation walls.

---

*) For each acre to be treated, dissolve 160 pounds of granular sodium cyanide in 12,000 gallons of water.

**) 1917. Hinds, W. E., Carbon Disulphide as an Insecticide; in Farmers' Bul. 799, U. S. Dept. Agric., Wash., D. C.

In tropical countries it may be necessary to lay a base of concrete*) for the entire building, after the soil has been poisoned.

How Termites Infest Buildings. — The principal methods by which termites get into buildings (text-fig. 2) are:

The use of untreated wood in basements, or the foundations of buildings, where termite damage is most likely to start.

The penetration by termites of masonry walls where improper grades of mortar have been used in foundations, the insects thus working up through the interior of walls.

Through earth-like shelter tubes by means of which termites are able to crawl up over impenetrable walls and thus infest buildings.

Insulation. — Complete insulation from the ground of all untreated woodwork of buildings is the only effective permanent preventive or remedy against attack by subterranean termites. These insects must maintain contact with the ground to obtain the moisture necessary for their existence. When contact with their moisture supply in the earth is cut off, the insects in the damaged wood, no matter how numerous, soon dry up and die.

Concrete Flooring. — There should always be a layer of solid concrete at least one inch thick laid over the coarse gravel, cinders or cement grout base of concrete floors (text-fig. 1). In the tropics concrete floors are advisable for the entire building.

Protection of Basement Construction essential. — Irrespective of whether the proposed building, as to its main construction, is to be of masonry or wood, it is highly desirable, where practicable, to eliminate wood from foundations, cellars, and basements. This means the substitution for wood of concrete or similar material for basement floorings, as well as the elimination from basements of any other structural wood, including wood substitutes, such as fibre and composition boards, and other substitutes containing cellulose. This prohibition, of course, does not apply to movable furniture.

Timber or lumber can be safely used in buildings, where the principal damage is caused by subterranean termites, if it is raised a suitable distance above possible soil contact by rock, concrete, or brick foundations made with standard grades of mortar, or suitably capped, and if metal shields are put on to shut off passage or shelter tubes (text-fig. 3).

Modifications of City Building Codes. — One of the simplest and most effective means of prevention of attack would be to modify the building regulations or codes of various cities so as to include a few simple rules in the mandatory code to protect houses from damage by termites. These suggestions are as follows:

PROVISIONS FOR BUILDING CODES FOR INSURING PROTECTION FROM TERMITES AND DECAY.

Wood or fiber products, when not impregnated with an approved preservative, shall not be placed in contact with the earth or within 18 inches thereof, excepting

*) 1919. Oshima, M., Formosan termites and methods of preventing their damage; in Philippine Journal of Science, vol. XV, no. 4, pag. 319—384, Pls. I—XIII.

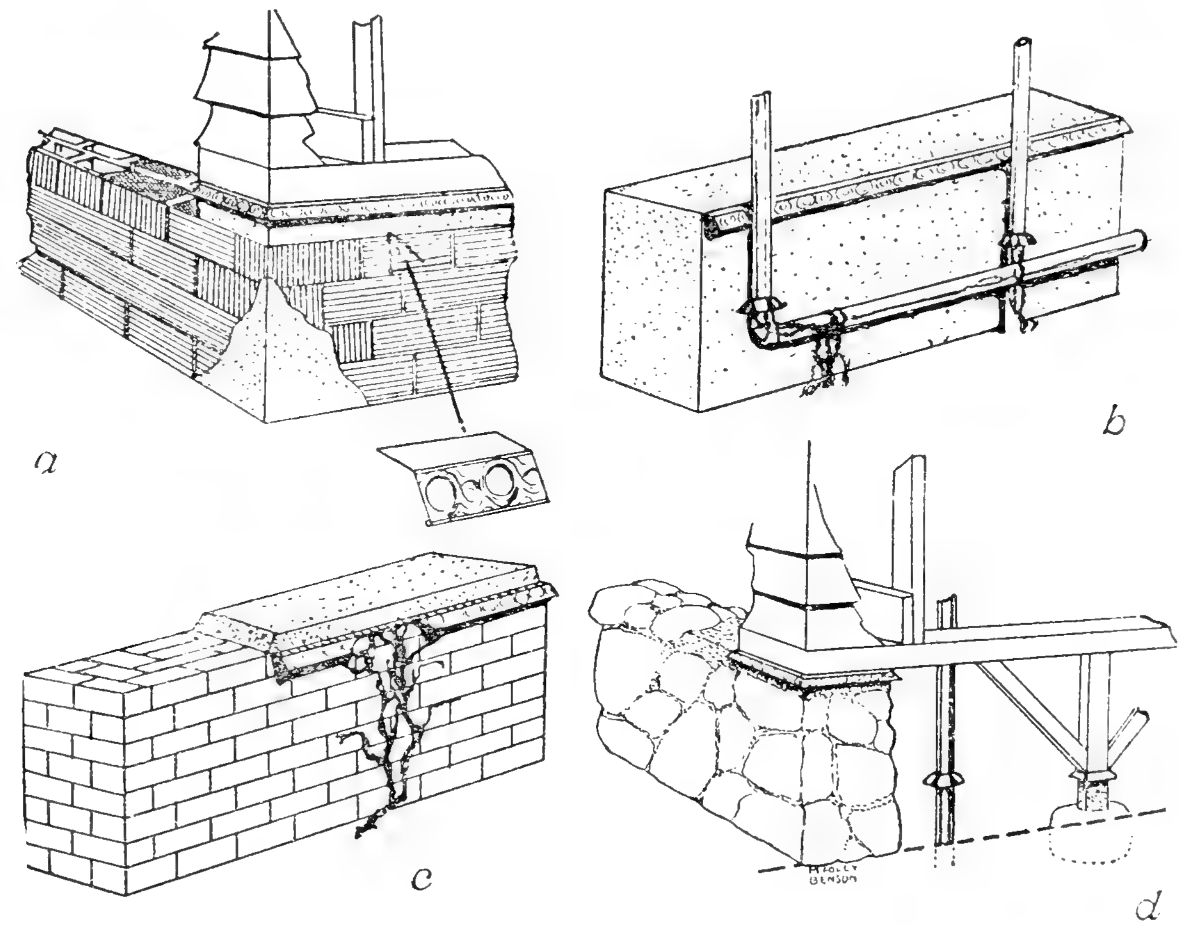


Fig. 3.

The insulation of hollow and solid masonry foundation units against termites.

(a) Foundation wall of hollow tile surfaced with stucco, showing metal termite shield in place and how the top of the wall is capped with sheet slate and concrete.

(b) Concrete wall with termite shield at top and horizontally laid piping fitted with metal shield above bend to shut off termite tubes.

(c) Brick wall with termite shield and capped with concrete; note how the shield mechanically blocks the earth-like shelter tubes of the termites.

(d) Stone wall with termite shield and capped with concrete, and wooden posts insulated from the ground with base stone and concrete block. Note termite shields on post and piping.

wood columns or posts over a concrete floor, which columns shall be provided with noncorroding metal or concrete base plates or footings 6 inches above the floor. This applies to steps, which shall be laid over a concrete base, projecting at least 6 inches beyond the supports of the steps.

Timber to be used in contact with the earth shall be thoroughly impregnated by a standard pressure process with coal-tar creosote or other equivalent preservative. Timber should be completely framed before treatment, whenever possible, but when cutting after treatment is unavoidable, the cut surfaces shall be thoroughly coated with coaltar creosote or other equivalent preservative.

Masonry foundations and footings shall be laid in Portland cement mortar. Foundations built up of masonry units, whether hollow or solid, shall be capped below woodwork with at least 1 inch of Portland cement mortar, or this mortar and slate, or solid or joined noncorroding metal, or other equally efficient seal.

In the case of frame buildings, a metal termite shield shall be provided, continuing completely around the top of the masonry foundation, including all pillars, supports, and piping, below the woodwork of the building, on both the inside and outside surfaces. Such a shield may be formed of a strip of noncorroding metal (such as copper, zinc, or an alloy of copper 28%, nickel 67%, iron, manganese and silicon 5%) firmly inserted in the surface of the masonry, or between the foundation and the wood, with the projecting edge bent downward at an angle of 45 degrees and extending horizontally at least 2 inches from the face of the foundation. In masonry buildings this shield can be inset in the masonry at a height at least 18 inches above the ground.

Floor sleepers or joists imbedded in masonry or concrete, or laid on concrete which is in contact with the earth, shall be impregnated with an approved preservative.

Expansion joints between concrete floor and wall shall be filled with liquid asphaltum, and the right angle joint covered with a sanitary cement mortar or Portland cement concrete finish of an arc of at least 2 inches in length.

The ends of wooden beams or girders entering masonry or concrete shall not be sealed in, but shall be provided with boxes affording an air space at the end of the piece of not less than 1 inch at side of member, unless the ends of such timbers are impregnated with coal-tar creosote or other approved preservative.

Where there are spaces under floor near the earth, they shall be excavated so that there will be no earth within 18 inches of the wood, and they shall be provided with cross ventilation. Such ventilating openings shall be proportioned on the basis of 2 square feet for each 25 lineal feet of exterior wall, except that such openings need not be placed in front of such buildings. Each opening shall be provided with 20-mesh non-corroding metal screening, including windows in attics.

Where timber is used in roofs of the flat type, the roof shall, unless protected on the weather side with a covering impervious to water have a slope and run-off sufficient to provide proper drainage.

All wooden forms on foundations shall be remvoed from masonry work within 15 days; grading stakes should be removed before laying concrete floors.

Cost of Termite-Proofing slight. — A few hundred dollars additional spent in the beginning in proper building construction may save thousands of dollars in repairs and replacements later. It is much simpler and cheaper to keep termites out of a building than to get rid of them after they are once in, and repair the damage, which may often be too costly for the small householder. The carrying out of these suggestions for the prevention of termite damage to building will probably add from 1 to 2% to the initial cost of the building (mainly chargeable to supervision), but this outlay will be a form of insurance, not only to the householder, but to the person financing the building. Bankers have shown their understanding of this point by their willingness to loan more money or give a lower rate of interest to a home owner constructing a building in accordance with these provisions.

The impregnation with a standard preservative of all woodwork to be used in the building where there is considerable damage by dry-wood termites is recommended as a further precaution to persons who can afford the expense of it, but it increases the intitial cost of termite proofing to approximately 10 per cent.

C. Mound-Building Termites.

Certain tropical termites build large earthen mound nests of more or less hard texture. By means of subterranean galleries termites from these nests may attack crops or the woodwork of buildings.

The inhabitants of some of these mounds may be poisoned by calcium cyanide (2 ounces per square yard of ground, inserted in a number of holes) or gases such as used with the "Universal Ant Exterminator", or others.

In cases of other mounds, it may be necessary to destroy them by means of explosives (1) placed in a series of holes drilled in the mound; then the nest material is broken up, the ground ploughed and the soil poisoned.

EXPERIMENTS WITH WOOD PRESERVATIVES.

In connection with the recommendations of the Bureau of Entomology for the protection of the buildings from attack by termites, certain ex-

periments are being conducted. Since 1912 the Bureau of Entomology has been conducting experiments at Fall Church, Virginia, in part in cooperation with the Forest Products Laboratory, with various chemical wood preservatives to determine those most effective in protecting wood against the attack by termites. Chemical treatments are also being experimented with for wood pulp and fiber products, such as wall-board and the various composition boards, of all which are subject to attack by termites.

In addition to the tests conducted in continental United States, supplementary tests were begun in 1924 on Barro Colorado Island, Canal Zone, Panama. Here chemical preservative treatments, not only for timber in contact with the ground but also for interior woodwork, cabinet work and furniture, are being tested. Inspections of these tests are made periodically.

To date the most effective preservative treatments for timber in contact with the ground is impregnation with coal-tar creosote. For timber not in contact with the ground, impregnation with zinc chloride has proven most effective. These are the standard chemical preservative treatments recommended by the American Wood Preservers' Association.

These experiments are still under way, are being added to, and probably will be continued for many years in the endeavor to discover more effective and cheaper preservatives than those now recommended as standards.

Recently, in cooperation with the Forest Products Laboratory, four sets of test timbers, each set impregnated with fourteen different preservatives, have been shipped to South Africa, Australia, Hawaii and Panama. Entomologists of the various local governments will make yearly examinations and reports on how these preservatives protect the wood from attack by termites.

It is believed that these tests, which include timbers impregnated with standard preservatives, will demonstrate the effectiveness and practicability of wood preservatives as a method of preventing insect attack and serve as educational propaganda.

DEMONSTRATION TERMITE-PROOF BUILDING.

On Barro Colorado Island, a model demonstration termite-proof building was erected in cooperation with the American Wood Preservers Association during August, 1926. This building was constructed entirely of wood, all of which had been impregnated before framing with such effective standard preservatives as coal-tar creosote and zinc chloride; the treatments were made by both full and empty cell pressure processes of impregnation. The treatment selected in each case was that most suitable for the position of the timber or lumber in the structure. Thirty species of wood-destroying termites occur in the tropical jungle on Barro Colorado Island. At the last examination, made on Feb. 19, 1929, this building had not been attacked by termites.

In view of the fact that but few termite-resistant woods occur in the world, it is recommended that, in general, commercial woods be impregnated with standard chemical wood preservatives, rather than to attempt to obtain termite-resistant woods.

On Barro Colorado Island during April, 1927, several buildings and a tower were also erected of redwood *(Sequoia sempervirens)* from the Pacific Coast to determine the resistance to attack by termites of a special grade of close grained heartwood redwood. An examination on Feb. 19, 1929, revealed no penetration of the wood by termites.

TESTS OF MORTARS FOR FOUNDATION WALLS.

Tests of mortars and concretes of various different chemical and physical combinations, as well as the inclusion of poisons in the mortars, are also being conducted by the Bureau of Entomology to determine the most effective combination for foundations below the surface of the ground for the purpose of preventing penetration by termites. Some termites, subterranean in habit, are able to dissolve certain grades of lime mortars. At Falls Church, Virginia, 16 test walls or panels were constructed in August, 1926. Other similar test walls were built by the Bureau of Standards at Washington, D. C., and by the State Entomologist at Urbana, Illinois, in 1927, in cooperation with the Bureau of Entomology. These will be rather long time tests, although certain grades of mortars have already failed.

Literature.

1. 1924 Snyder, T. E., and Zetek, J. Damage by termites in the Canal Zone and Panama and how to prevent it; in Bull. 1232, U. S. Dept. Agric., Wash., D. C.
2. 1926 Fullaway, D. T. Termites or white ants in Hawaii; in The Hawaiian Forester and Agriculturist, Vol. XXIII, No. 3, pp. 68—88, July—Sept.
3. 1926 Snyder, T. E. Prevention of damage by termites or white ants; in Farmers' Bul. 1472, U. S. Department of Agriculture.
4. 1926 —, The biology of the termite castes; in Quarterly Review of Biology, Vol. 1, No. 4, pp. 522—552.
5. 1927 —, Termites modify building codes; in Journal of Economic Entomology, Vol. 20, No. 3, pp. 316—321.
6. 1928 —, How to prevent termite damage to buildings; in Engineering News Record, Vol. 100, No. 7, pp. 274—276.

The Mutual Relations of Museums and Expert Specialists.

Dr. W. J. Holland, Pittsburgh, Penna.

In the spring of the year 1899 (twenty-nine years ago) I had some correspondence with a gentleman, long since dead, whom I asked to determine for me the moths belonging to a certain group, upon the classification of which he at the time was recognized as an authority. He was not officially connected with any institution of learning. The moths were in part the property of the Carnegie Museum, and in part in the custody of the Museum. He expressed willingness to undertake the task, but only upon the condition, formulated by him, that "according to the unwritten, but universal, law, he should be allowed to retain for his own private collection anything which he might be pleased to retain". He went on to say in his letter: "It is the indefeasible right of an expert to take anything he wishes out of collections submitted to him for determination."

The position assumed by my correspondent being at variance with my own extensive experience I was somewhat astonished; but to better inform myself, I wrote a circular letter to a number of my scientific friends and correspondents in America and Europe, asking them to state the usage known by them to prevail, and requesting the privilege of quoting their answers. To facilitate response I enclosed a printed slip, or questionnaire, which left space for brief replies. The questions I put were as follows:

1. Is it "the unwritten but universal law that an expert to whom scientific material is submitted for study is entitled to retain therefrom anything he pleases?"

2. Does the institution with which you are connected recognize it as "the indefeasible right of an expert to help himself to anything he wishes out of collections submitted to him for determination?"

In due course I received replies from nearly all of the persons whom I had addressed. Many of them, in addition to writing brief replies to the two questions on the slips, wrote letters, some of them quite long, fully discussing the subject called to their attention. The whole body of this interesting correspondence has long lain in my letter-files, and very many of those who wrote to me have passed into the realms of eternal light. The subject, however, is still of interest, and not infrequently comes up for discussion. It has, therefore, occurred to me that it might be proper, even at this late date, to give to the world some of the replies which I received, and to present a brief resumé of the conclusions as to practice to which they point.

In the vast majority of cases the replies to the two questions were emphatically in the negative. In a few cases negative replies were accom-

panied by qualifying statements. The replies received from botanists indicated a method of procedure somewhat different from that generally followed by zoölogists.*) The replies received from several members of the staff of the British Museum and certain English friends brought out the fact that the subject in that institution had been brought under regulation by an Act of Parlament, and that during the hours of official employment the curatorial force is prohibited from rendering any service to other institutions or to individuals, unless the material submitted for study is allowed to be incorporated in the collections of that museum, an exception being made, when that museum itself has *borrowed* material for study from other institutions.

Categorically negative answers, without further comment, were received from C. E. Beecher, Peabody Museum, Yale University; Dr. Henry Fairfield Osborn and Dr. J. A. Allen of the American Museum of Natural History, New York City; J. H. Comstock, Cornell University; H. J. V. Skiff of the Field Museum, Chicago; James Reeve, Curator of the Castle Museum, Norwich, England; Professor W. C. M' Intosh, St. Andrews University, Scotland; Professor Adolf Weismann of the University of Freiburg; Prof. Ernst Haeckel of the University of Jena; Dr. Karl Möbius, Director of the Zoölogical Museum, Berlin; Prof. E. Ehlers of the University of Göttingen; Dr. Karl Zittel, Director of the Paleontological and Geological Museum in Munich; and Dr. Franz Steindachner, Intendant of the K. K. Hofmuseum of Natural History in Vienna.

Emphatic negative replies to both questions, accompanied by more or less brief comment, were received from C. H. Gilbert, U. S. Geological Survey; Prof. F. M. Herrick, Western Reserve University; Prof. Wm. B. Scott and Prof. J. B. Hatcher of Princeton; Albert P. Morse of Wellesley College; Prof. A. S. Packard of Brown University; Prof. E. A. Popenoe of the Kansas Agricultural College; Dr. Alpheus Hyatt, Curator of the Boston Society of Natural History; Prof. E. A. Birge of the University of Wisconsin; Prof. C. O. Whitman of the University of Chicago; W. K. Brooks, Johns Hopkins University; Dr. Burt G. Wilder; Dr. James Fowler of Queens University, Kingston, Ontario; Prof. J. W. Carr, University College, Nottingham, England; James Paton, Superintendent of the Glasgow (Scotland) Museums and Art Galleries; Dr. Henry Woodward, Keeper of Geology, British Museum, London; M. D. Hill, Director of the Museum of Eton College, Windsor, England; H. Bolton, Curator and Secretary of the Bristol (England) Museum. The latter gentleman was most severe in repudiating the two claims of my correspondent.

Qualifiedly negative replies were received from two of my most valued friends, Dr. Samuel H. Sudder of Cambridge, Mass., and

---

*) The usage among botanists seems to be *(fide Trelease, Coulter, et al.)* to submit to the expert specimens, or parts of a plant, designated by a fixed number, corresponding with that attached to the material retained by the sender, and such retained portion is accepted as the "type", when a name is given by the expert, unless an arrangement has been made in advance that the identical specimen sent to the expert shall be by him returned as being the "type".

Dr. S. W. Williston, the celebrated Dipterist and Paleontologist. Both wrote from the standpoint of the expert rather than from that of the official representative of a museum. Dr. Scudder remarks that the first claim of my correspondent "is entirely too sweeping"; but goes on to say that an "expert of recognized standing" should have the "*privilege*" of retaining "specimens of species which he may have named, for future reference in later studies". The second query Dr. Scudder answered in the negative. Dr. Williston, while replying to both queries in the negative, added the comment: "It is usually an imposition to ask an expert to study a heterogeneous collection of specimens, unless he be permitted to retain *duplicates*. Only under exceptional circumstances will I describe a new species, unless I am allowed to keep the type." But Dr. Williston, at the time he wrote, was only one of less than half a dozen persons in America who knew anything about the Diptera, or collected them systematically.

Professor Charles H. Fernald, the celebrated authority upon the Microlepidoptera, with whom I exchanged several letters, also wrote in the main affirming the contention of my correspondent to be excessive, but speaking from the standpoint of the expert rather than that of the custodian of the collections of a museum, maintained that it should be the right of an expert to rescue for science from collections sent to him for determination representatives of species new to science which might be lost or destroyed. "If I should find in a collection sent to me by a school-boy to be named an insect new to science, I should be recusant to my duty, if I did not retain that specimen and keep it for the information of future students." Of course. There are such cases. But as a rule "school-boys" can easily be persuaded to render service to science, and are proud to do it.

Only one of my American correspondents answered the queries addressed to him with an unqualified affirmative, and, he being long since gathered to his fathers, shall be nameless. He was a well known Coleopterist in his day.

I venture from the letters which lie before me to give the replies received from a number of distinguished men, whom I have not mentioned in the preceding lines, as they tend to throw light upon the subject.

A characteristic letter was received from the late Dr. Alexander Agassiz:

April 14, 1900.

"My dear Sir:

I cannot imagine what maniac wrote the above [referring to the claims printed in my questionnaire]. He must have an exaggerated opinion of himself. No such right is, or has been, recognized by the large number of specialists who have assisted me in working up the collections entrusted to them for determination.

One entomologist, who shall be nameless, attempted to help himself in accordance with the "unwritten law". When it was discovered that he had *stolen* specimens from the collection sent him for examination, he was asked to return them. On his refusal a suit was instituted and the specimens were at once returned with a letter of abuse against an

institution which was so mean as not recognize this "universal law" of theft.

I have always considered the loan of a collection and of new material an ample reward, but have generally sent duplicates which could be spared in return for other things from the expert or student to whom our material had been sent.

Yours truly A. Agassiz."

Professor A. E. Verrill of Yale, after answering both of the inquiries on the slip in the negative, wrote that on only two occasions had he known such claims to be set up, once by an Entomologist and once by a Conchologist, and adds in substance:

"We generally ask, when naming collections for others, a set of duplicate specimens (in case there be any that we need), but when another names collections for us, we never allow him to retain single or unique specimens, or single types of new species. If we particularly desire rare specimens in collections submitted to us to be named, we try to obtain them by exchange or purchase. We consider such things as valuable property to which no one has any right but the owner, and we, when we wish them, endeavor to bargain for them. We recognize no *right* on our part to appropiate them."

Dr. Leonard Stejneger of the U. S. National Museum, after replying in the negative to the two questions, says:

"It is understood, however, that, if a collection is submitted to any of the experts of the museum for identification, he may retain a *duplicate set* for the museum."

The response of Dr. A. Hopkins of the U. S. National Museum was in substance the same as that of Dr. Stejneger.

From Dr. L. O. Howard of the U. S. Department of Agriculture I received the following:

March 28, 1900.

"Dear Dr. Holland:

Your circular letter of March 9 was received during a recent absence from the city, but I now enclose a reply to your questions. I always take the precaution to have a distinct understanding with an expert to whom scientific material is sent for study. Nearly always, as you know from your own experience with us, we require the return of material sent, though expressing ourselves as willing to present duplicate material in return for the services of the expert. I think, it must be admitted, however, that the standing of the National Museum is, of right, a little more rigid than is absolutely necessary for small and remotely situated museums. The National Museum should contain the largest number of types. There are a few museums upon nearly the same plane as regards size and accessibility (geographically speaking). Among these I should include the Museum of Comparative Zoology in Cambridge, the American Museum of Natural

History in New York, the Academy of Natural Sciences in Philadelphia, and the Carnegie Museum in Pittsburgh. These institutions, I should think, would have a perfect right to make their rules as rigid as those which I have just mentioned. At the same time, however, I realize that there may be very rare cases where such a rule might be slightly altered to advantage.

Sincerely yours L. O. Howard, Entomologist."

Dr. E. P. Bigelow of the Massachussetts Institute of Technology and the Marine Biological Station at Woods Hole, answered both queries in the negative, saying:

"By no means! When an author sends a book to be reviewed, the reviewer is expected to keep the book, but this does not apply to scientific specimens. If the question were to come up with us, I am sure we should follow the precendent of the U. S. National Museum, and the U. S. Fish Commission, and request the return of the specimens."

From the Director of the Peabody Museum at Harvard I received the following:

"My dear Dr. Holland:

I think the questions can be answered as follows:

As a Curator of a museum the specimens under my charge are not mine to dispose of, and if an "expert" wishes to use any of the specimens for study he certainly has not right to keep them. If an expert should make an examination of material at my request, I should expect every specimen returned, unless a regular agreement had been made with him in relation to retaining certain specimens, such agreement having been duly approved and recorded.

F. W. Putnam."

Dr. P. R. Uhler, the Director of the Peabody Museum in Baltimore wrote as follows:

In reply to query No. 1:

"No such law or rule has ever been brought to my notice. I have determined the hemipterous insects of America for correspondents in Europe, India, Japan, Australia, Canada, Mexico, and the U. S., but always with an understanding what I could keep, and which were to be returned."

In reply to query No. 2:

"By no means! Insects are often so common that but little value is placed upon specimens of them, but such is not the case with most of the choice specimens which fill up the modern museums."

The following letter from one of the great geologists of America is interesting. He writes not so much from the standpoint of the Museum, as from that of the expert.

Berkeley, Cal., March 27, 1900.

"Dr. W. J. Holland,

Dear Sir:

Instead of answering your pointed questions categorically I will simply give you our own custom on the subject.

There is, so far as I know, no law, written or unwritten, on this subject. Our own custom is to determine such material as is sent to us, but always with the *request* that duplicates may be retained. Each case is treated by itself. But of course without the privilege of retaining duplicates, if wanted, one would soon tire of determining.

Very truly yours Joseph Leconte."

From Professor Henry F. Nachtrieb of the University of Iowa came the following:

In reply to Query No. 1:

"No! Judging by my experience, I should say the "expert" maintaining this proposition lacks the spirit of a true scientist."

In reply to Query No. 2:

"No! When I run against such an "expert" his name is dropped from our list. However, whenever possible, I offer duplicates to the expert. I have not had any dealings with the kind of kleptomaniac you seem to have in mind, but feel sure that some of the collections donated to my department, and which others had been allowed to examine for the purpose of identification, must have passed through a bunch of adhesive tentacles. In all cases it is well to have an understanding with the expert before submitting any valuable material to him."

Dr. H. A. Pilsbry, the celebrated Conchologist, in charge of the great collections of Molluscs at the Academy of Natural Sciences in Philadelphia, wrote in reply:

Query No. 1. "Never heard of such a law. The costumary rule is to allow the expert to retain the first series of duplicates. The possession of unique specimens is usually the subject of special arrangement in each case."

Query No. 2. "It [The Academy of Natural Sciences] has never been called upon to rule upon the subject, although no institution in America has been more active in working up zoölogical material for naturalists throughout the world. So far as I know, our zoölogists follow the custom mentioned above. We would not admit that an expert had any such right [implied in 2] in dealing with our material. I am somewhat surprised that anyone should seek to enforce such a "rule" against an institution of learning, for curators of such bodies are rarely given power to dispose of the specimens on such a basis."

Professor G. H. French, the well known author of "The Butterflies of the Eastern United States", wrote:

"I have answered No to both of your questions. I have known, however, for some years that a few have made the claim that they were to take for their services what they pleased of material submitted to them for identification. I let such fellows alone."

"I have had material identified for me by yourself, Grote, W. H. Edwards, Henry Edwards, Strecker, Horn, Williston, who come to my mind, without any such claim. I have identified material for a great many, and never made such a claim. If there was anything which I wanted, I asked for examples after returning the identified specimens, and often got what I wanted." . . . . . .

From my good friend, Mr. F. D. Godman, the Editor and Publisher of that monumental work, the Biologia Centrali-Americana, in the production of which he expended a princely sum, I received a letter from which I quote:

"In working out the material for the Biologia Centrali-Americana I have had considerable experience in the matter on which you write to me, as I have had to solicit the assistance of many gentlemen in England and on the continents of Europe and America. My practice has been to secure a first set from the material, which I have given to our British Museum, and I have then offered a second set of the insects, or whatever it might be, to the gentleman who has undertaken the work, and, so far as I know, this has given satisfaction."

Dr. Karl Jordan of the Zoölogical Museum at Tring wrote me:

"The work of classifying often becomes very dry; your letter regarding the 'universal law' maintained to exist by one of your correspondents, shows, however, that there is some 'fun' to be derived from it." Dr. Jordan says to both queries:

"Certainly not! Such a 'law' would mean that the Curators of museums, soliciting the help of specialists, would ruin the collections which they are bound to care for, the best material being that which the expert would like to keep for himself. The museum would change from a storehouse of scientific collections into an establishment for distributing specimens 'gratis' among specialists."

"It is the rule in the Tring Museum that the insects which are sent to a specialist for determination must all come back; but the specialist will receive for his work one or two (or more) examples of each species which he determines according to the number of specimens at our disposal, uniques excepted. On the other hand, we do not *insist* on specialists describing new species from single examples. If specialists *borrow* material from the Tring Museum, every specimen has to be returned, and it must be left to us to decide whether the specialist may receive some specimens as a present."

From the above correspondence, which represents the views of many of the most distinguished authorities of the past and the present, certain conclusions may be drawn.

1. Scientific material is property, the right to the possession of which is vested in its owner *absolutely*, and which can rightfully only pass from its owner by sale, gift, or exchange.

2. Curators, custodians, keepers, or other officials, in scientific institutions, however they be named, have no right to dispose of scientific material in their custody, unless they have been authorized to do so by formal action of the Trustees, Regents, Governors, or whatever may be the title of the body in whom the property of the institution may be legally vested. If such holding bodies have given the discretionary right to the Chief Official representing them to dispose of property in their custody by sale, gift, or exchange, he may do so, as their representative, thereto authorized; but he should always report his action to the governing board for their approval. Minor officials in charge of sections in a Museum should never be allowed the right to dispose of any of its property,

without having been authorized to do so by the responsible head, or owner of the institution.

3. Where material is sufficiently abundant and there exist genuine duplicates, it has been and is now the universal custom for scientific institutions to grant the expert, who has solicited it, the right to receive from material submitted to him, as many duplicates as it may appear to the authorities of the institution proper for them to grant to him, as being in measure a compensation for the services he has rendered them in his work of determination; but the expert has no "indefeasible right" to take out of collections submitted to him for determination "anything which it may please him to retain," whether he be acting as a private individual, or as a representative of a public institution.

4. Types and material made the subject of description and publication should always be returned to their original owners, unless a mutual agreement has been made and recorded to the contrary.

5. Sound administration in any museum of record demands in general that a written record in every case of a contract with experts should be preserved.

I pass on to the consideration of matters involved in this discussion from the stand-point of the expert. The expert is presumably the possessor cf certain qualifications which belong to him as the result it may be of years of study. He has become a past-master in his specialty. It is as true of him as of others, that "the laborer is worthy of his hire". Some men exist who find pleasure and honor in having such tasks confided to them. They work solely impelled by the love of the subject. Perhaps in independent circumstances, some of these specialists would even resent the idea of monetary compensation. There are not a few such men among Entomologists, be it said to the great glory of our profession. But viewed from the broader standpoint of rectitude in dealings as between man and man, I hold that an institution of learning, which needs and therefore solicits the services of the expert, should make it a rule at least to endeavor to grant him an adequate return for his services, whether "in kind, or in cash".

The boundaries of the biological and other sciences have grown so vast that no one institution is able to employ and pay the salaries of the almost numberless specialists, whose services are from time to time required. It becomes a necessity and even a duty therefore to invoke and obtain the services of experts. Such experts should always, if possible, be rewarded according to the proprieties of the case, finding compensation: it may be in the publication and illustration of their work; it may be in the grant of duplicate material; it may be in financial compensation, based upon an agreement formally entered upon between themselves and the institution temporarily employing them in their leisure hours.

For at least sixty years more or less of a specialist, and for more than a quarter of a century at the head of one of the greatest museums in America, I have summed up the foregoing conclusions with a confidence which my acquaintance with men of science and my experience as an administrator persuade me that I have a right to feel and with which I hope you all agree.

The Present Status of the Leopard Moth, Zeuzera pyrina L., in the United States.

W. E. Britton, State Entomologist, New Haven, Conn.

Occurrence in the Old World.

The leopard moth is recorded as occurring in Central and Southern Europe, Northern and Southwestern Africa, Asia Minor, and Mr. South states that it is present in Korea and Japan.

History and Distribution in the United States.

It is not known exactly how or when this insect came to the United States, but a living female moth was captured in a spider's web at Hoboken, New Jersey, in 1879, so it must have been introduced here fifty or more years ago, and probably came from Europe.

Considering New York City as a focus, and that this pest of shade trees has been here fifty years, we must conclude that it has spread very slowly, for it now occurs only in the New Jersey and New England coast region from the latitude of Philadelphia nearly to the northern boundary of Massachusetts.

Recent correspondence has brought the following information:

Mr. H. B. Peirson writes that he has no records of the occurrence of the leopard moth in Maine. Professor W. C. O'Kane has no evidence that the insect occurs in New Hampshire. Professor A. I. Bourne of Amherst and Professor C. T. Brues and Mr. C. W. Johnson of Boston have sent me records from Massachusetts, but all are from the eastern end of the state, the westernmost station being Shrewsbury just east of Worcester and about forty miles from the coast. One record is from the Island of Nantucket. Apparently the leopard moth occurs throughout Rhode Island. In Connecticut this insect is present in all of the cities and villages near the coast, the farthest inland point of which we have record being Hartford, about forty miles from the coast.

In New York State, the leopard moth is found on Long Island, Staten Island, New York City, in Westchester County and in the lower reaches of the Hudson River Valley. The "List of Insects of New York", issued in 1928, gives the range of the leopard moth as "New York City and north to Ossining in Westchester County: also reported injurious to apple in Orange County". Professor P. J. Parrott has reared the moth from material collected at Kingston. Howard and Chittenden in Farmer's Bulletin No. 708 (1916) published a map showing the distribution of this insect, which indicates that the leopard moth not only occurs as far north as Kingston but is recorded in the northern part of Washington

County in the Lake George region: it is also recorded for Columbia, Ulster, Dutchess and Orange Counties, but no definite records or details are given for any of these localities.

Dr. T. J. Headlee writes as follows: "*Zeuzera pyrina*" occurs practically throughout the state of New Jersey, and is found in orchards along the Delaware River as well as along the Atlantic Coast. I have heard very little of its work in orchards in the mountainous sections of northern New Jersey".

Dr. T. L. Guyton, in Pennsylvania, informs me that the leopard moth occurs only in the extreme eastern end of the state around Philadelphia. A correspondent from Pineville in Bucks County, just north of Philadelphia, writes that the insect has caused much damage there.

Dr. H. L. Dozier has no evidence that the leopard moth occurs in Delaware, and Professor Ernest N. Cory states that so far as he knows it does not occur in Maryland.

The foregoing reports indicate that the leopard moth in the United States occupies a narrow area extending from the vicinity of Philadelphia along the coast to the northern boundary of Massachusetts, and probably not more than fifty or sixty miles in width. The American Museum of Natura History in New York City, and the United States Museum, Washington, D. C., could furnish no records of its occurrence outside of this area. The slow rate of spread may perhaps be due to the fact that the heavy females fly only short distances.

Destructiveness as a Pest.

The destructiveness of the leopard moth was observed in New York City as early as 1884, and in 1894 Dr. E. B. Southwick pronounced it one of the worst insect pests attacking shade trees.

Though the leopard moth was reported from Connecticut in 1894 by Pike, the first definite record that has come to my knowledge is that moths were collected in Bridgeport in 1901 by H. M. Russell.

The first record from New Haven was in 1907. By 1910 the trees showed much injury and many fine old elms could not survive the attack of the leopard moth after having been repeatedly defoliated by elm leaf beetle and mutilated by the many excavations and street improvements incidental to the development of a modern city. Between 1910 and 1920, this insect continued to raise havoc with the shade trees in all of the cities and larger villages along the coast. It also injured trees in Wallingford, Danbury, and other places a few miles inland, but has been found only at rare intervals in the open country.

Likewise in 1909 this insect was first discovered in the trees on the Harvard Campus at Cambridge, Massachusetts, and soon became destructive to the trees in nearly all of the cities and towns in and around greater Boston.

Dr. J. W. Chapman, who studied this insect in Boston and published a bulletin about it in 1911, considers that there is much evidence pointing toward an independent introduction from Europe into Massachusetts at a later date than the New York infestation. This is quite plausible as Boston had been a great center of importation of all kinds of trees and shrubs for many years.

From all observations and reports it seems that at present the leopard moth is somewhat less destructive to shade trees in the cities and towns where it occurs, than it was from ten to fifteen years ago. On the other hand it is reported as becoming an important orchard pest in New Jersey. Occasionally it is found in orchard trees, and even in small fruit trees in the nursery in Connecticut.

The large tunnels in branches from one to three inches in diameter, often girdle and weaken the branches so that they break off during storms. After a severe thunder storm in New Haven, July 24, the streets were literally strewn with broken branches, many of which had been partially severed by the burrows of the leopard moth. In most cases the galleries were old ones and had not been made this season.

Life History.

The eggs are laid singly or in groups of two or more on the trunk or branches, usually in crevices or under the edges of loose bark. Each female may lay from 400 to 800 eggs, the average being about 500, and the eggs hatch in from ten to fifteen days. The newly-hatched larvae crawl to the twigs or young shoots where they tunnel toward the tips, until the twigs wither, or are too small for the tunnels of the rapidly growing larvae; they then leave the twigs and enter other branches or perhaps the same branch where it is larger.

The larva scarcely reaches an inch in length by the end of the season and hibernates in its tunnel in the twigs. The following spring it feeds actively and may leave its branch and go into another branch or the trunk of the tree where it continues to tunnel in the wood. It makes frequent outlets through which the frass is discharged. These holes are circular, about one-eighth of an inch in diameter, and are immediately closed with a white web. On the approach of the second winter the borer eats a slanting hole upward and deeper into the solid wood, making a safe chamber in which to pass the winter. The following spring it continues its work until May or perhaps later, when it transforms to a brown pupa within the tunnel just beneath the bark. Before pupating, the borer cuts an exit hole almost through the bark and from this hole the moth emerges four to six weeks later, leaving the pupa skin protruding from the burrow.

The adult moths have only a brief period of life. The males die soon after mating and the females die soon after laying eggs. They may be found from May to September, but reach the height of their abundance in July, in Connecticut.

Appearance of the Insect.

Both sexes of the moths have black bodies cross-banded with white hairs, and white wings marked with small metallic blue spots or dots. The males have a wing-spread of nearly two inches and the females from two and one-half to three inches.

The eggs are oval in shape about one-sixteenth of an inch long and salmon or orange yellow in color.

The full grown larva may reach a length of two and one-half inches, is dirty white, dull yellow, or pink in color, marked with dark brown or

black tubercles each bearing a hair. The head, large cervical shield, and small anal shield, are dark brown. Legs are light brown.

Natural Enemies.

Though two or three Hymenopterous parasites of the leopard moth have been recorded in Europe, similar records seem to be lacking in this country. It is believed that birds are the most important agents in controlling this pest in the United States. The woodpeckers, particularly, drill into the branches and feed upon the borers and squirrels are said to gnaw into the burrows and devour the larvae.

Artificial Control.

With trees of small or moderate size, much can be done to check the ravages of this insect by pruning off and burning the small twigs which become infested. The presence of the larger borers may be detected from the sawdust pellets on the ground and the moist spots and slight discoloration often present around the openings. The whitish webs covering the circular outlets are also conspicuous on the bark of some kinds of trees. The borers in such galleries may be killed with a wire; by injecting a contact insecticide; or by introducing a volatile liquid the fumes of which are fatal to the borer.

American Literature.

The following are a few of the more comprehensive American publications dealing with this insect.

1. Britton, W. E., and Cromie, G. A., The Leopard Moth. Bulletin No. 169, Connecticut Agricultural Experiment Station, New Haven, Connecticut, 1911.
2. Chapman, J. W., The Leopard Moch and Other Insects Injurious to Shade Trees in the Vicinity of Boston; Bussey Institution, Harvard Univerity, Cambridge, Massachusetts, 1911.
3. Howard, L. O., and Chittenden, F. H., The Leopard Moth. Circular No. 109, Bureau of Entomology, U. S. Department of Agriculture, Washington, D. C., 1909. — Howard, L. O., and Chittenden, F. H., The Leopard Moth.: A Dangerous Imported Insect Enemy of Shade Trees, in Farmer's Bulletin, No. 708, U. S. Department of Agriculture, Washington, D. C., 1916

A Variable Palearctic Satyrid.

Dr. A. Avinoff, Director of the Carnegie Museum, Pittsburgh, Penna.

The group of *Satyrus huebneri* Felder is characterized by several peculiarities from a zoogeographic and taxonomic point of view. It includes over twenty forms showing a marked mutual affinity. They are distributed in the mountainous area of Central Asia from the northwestern ramification of the Himalayas forming the southern boundary, over Ladakh, Hunza, Pamir, Bokhara, the alpine sections of Russian and Chinese Turkestan to the Alexander Mountains forming the northern limit of their distribution. On the east these forms follow the system of the Tian-Shan Mountains to Korla. Though this group is thus strictly confined to the mountainous system of Central Asia, it is interesting to mention that there are two Satyrids in the Rocky Mountains of North America which might be looked upon as vicarious representatives of *S. huebneri* in the New World. The North American *Neominois ridingsi* Edw. and *N. dionysius* Scud. bear a striking likeness with some forms of *S. regeli* Alph. and *S. tancrei* Gr. Gr., this resemblance being mainly restricted to the exterior aspect of the insect. Anatomical characters show, however, that the systematic separation is more profound. The group of *S. huebneri* has been put by Frederick Moore into a special genus under the name of *Karanasa*, together with two more North Indian species which have, in fact, little to do with this cycle of forms. In this article the butterflies in question will be considered as belonging to the genus *Satyrus*, though there are good reasons for indicating several subgeneric divisions in this heterogeneous series of insects united now under the designation of *Satyrus*.

The facts related to the distribution of these forms still remain incomplete, though extensive material has been assembled in the course of the last thirty years through a more thorough exploration of the mountainous regions of Central Asia. The author had an opportunity to observe these butterflies in life during his travels in the Pamirs, Turkestan, and Northern India. The present data lead to some preliminary conclusions of a general interest. The taxonomic relationship of the various forms included in the group of *S. huebneri* Feld. were treated differently by various authors. Some entomologists were inclined to see only two or even only one species broken up into many subspecific variations. This view is advanced by the work of A. Seitz, and is followed by W. H. Evans and other lepidopterists. Grum Grzhimailo, the recognized authority on Central Asiatic Rhopalocera, is inclined to think that the group of *S. huebneri* comprises a series of independent species numbering between ten and fifteen.

The divergency in taxonomic valuation of this variable group of butterflies arises owing to certain peculiarities in their systematic affinities. A brief account of these facts constitutes the subject of this paper.

In studying systematically the group of *S. huebneri* we are encountering in the first place a small set of actually independent species. However closely they are related to other branches of this group, they do not show any true mutual intergradation. Besides, a microscopic study of the anatomy of the male discloses minute, but apparently constant, characters which permit one to assign a position of specific independence to *S. josephi* Stgr., *S. boloricus* Gr. Gr., and *S. pamirus* Stgr. and to some of the North Indian representatives. *S. alpheraki* Av. from the southern Pamirs structurally resembles *S. pamirus* from the Alai Valley, though both butterflies are quite different in exterior appearance. It would be probably correct to correlate them in a conspecific way, especially in view of some interesting intermediate forms which were captured in the western Pamir and still remain undescribed. They will be treated in detail in a special monograph on this group which is under preparation, and will be accompanied by descriptions of the new forms and by plates with photographic figures. The taxonomic position of *S. abramovi* Ersch. and *S. regeli* Alph. is somewhat questionable. The slight anatomical divergence seems to differentiate them with a considerable constancy, though this evidence cannot be taken conclusively. It would be safer, however, to classify them for the time being as independent units of the group with a sufficiently marked hiatus which seems not to be bridged up by intergradations. The balance of the group is constituted by a series of forms imperceptibly running one into the other. They comprise forms which bear the names of *S. dissoluta* Stgr., *S. intermedius* Gr. Gr., *S. wilkinsi* Gr. Gr., *S. leechi* Gr. Gr., *S. latefasciata* Gr. Gr., *S. tancrei* Gr. Gr., and others which can be arranged systematically in an uninterrupted sequence from almost uniformly russet or fulvous to black with white markings. If these forms were to be found in one single geographical region it would be easy to construe them as individual variations of the same exceedingly unstable species. If, on the other hand, each of these forms were the sole representative of the group in each definite locality, they should be looked upon as geographical races of the same species. The actual facts, however, are different and of a somewhat more complicated order. If, for the sake of a diagrammatic simplicity of the exposition, we shall give numerical designations to this row of forms, we observe that in one single point of their distribution frequently several members of the group are found, — for instance, Nos. 1, 5, and 10, but not the successive numbers. In some localities where we might encounter only two representatives of the group they often are the most remote members of the series. If we study the biological conditions in the actual habitat of these co-existing forms, we would note that they behave toward each other as independent species. They do not cross among each other, no intergrading forms are observed. A well-marked, systematic gap between these is plainly observable. Their biological independence seems to be perfectly established. They even exhibit different ecological preferences. So, it is interesting to mention that in some points of their distribution, namely, on the southern slopes of the Trans-Alai Mountains, the areas of the different forms, though

overlapping each other, are not entirely coinciding. In a certain habitat one can find, all flying together, *S. abramovi, S. wilkinsi,* and *dissoluta,* but as one ascends toward the northern border of Pamir one can register the different levels of altitudinal distribution: *S. abramovi* remains in the regions frequented by *S. wilkinsi,* which in its turn mingles at a higher altitude with *S. leechi,* where no *S. abramovi* are found any more. On the other hand, the intermediate form connecting the characters of *S. abramovi* and *S. dissoluta* is found in another locality, namely in Tian-Shan, where the highly variable *S. latefasciata* shows the interplay of both the black and white and the fulvous sections of the group.

Such a phenomenon presents definite difficulties for analyzing from a taxonomic point of view. The perfect intergradation uniting all the members of this group of *Satyrus* into one uninterrupted series precludes the breaking of this row into independent species. On the other hand, the fact that different members of the group simultaneously occur and act toward each other biologically as if they were separate species, does not allow one to classify them as races of one species as long as we have to uphold the accepted principle that a species can be represented in a given locality only by one subspecies. In view of such an involved complication it would be advisable to use another taxonomic terminology for similar cases, and the term vice-species is tentatively proposed for the purpose of describing such phenomena in order to preserve the prevailling usage of the terms species and subspecies.

One might surmise that we are witnessing in this case a species-in-the-making, breaking up into a number of branches, with the different tendencies clearly indicated. Some of the forms are gradually gaining a growing independence, and the intermediate forms are still preserved. Everytime such transitory forms are found elsewhere than in the habitat where other more extreme and divergent forms have reached a sufficient degree of differentiation, whereas the presumable formation of species is accompanied, as far as one can judge, by the extinction of intermediate forms and by the widening of the systematic gaps. In the case of *S. huebneri* we are observing a simultaneous coexistence of all these formative steps. These successive units are scattered in some cases in different sections of the general area occupied by the group and partly overlap each other in their destribution. The region of the Pamirs seems to be particularly appropriate for such a phenomenon since geologically the mountain ranges are of recent origin. It has been generally accepted that this mountainous system has been lifted up over eight tousand feet shortly before and during the Pliocene Period. One might presume that in the course of these geological processes the biological conditions favored the differentiation of local forms and brought about an intricate system of interpenetrating, intermediate links in this chain of related forms.

One could not find a more striking illustration of such a relationship and distribution among the Palearctic Lepidoptera. A certain approach, however, to a similar correlation is found in the case of *P. simo* Gray and *P. boëdromius* Püng. Though the forms of the *P. simo* group constitute a perfect transition to *P. boëdromius,* usually looked upon as a race of *simo,* in certain parts of the Tian-Shan one could find in the same place the typical *boëdromius* and a form of *simo,* namely *P. gylippus*

Fruhst., which, on account of the extreme development of the red ocelli, is the most remote from *boëdromius* with its plain black maculation. The features of the more complex case illustrated by *S. huebneri* is thus duplicated in principle, as the forms most unlike of the group are found together, while intergrading members of the chain constitute local races elsewhere. *P. simo gylippus* and *P. boëdromius*, in the place of their joint habitat, conduct themselves as independent species, but to find their systematic connections we have to go to Pamir, Chitral, and Tibet. The case of *P. boëdromius* and *P. simo* was treated at some length in a general revision of the group given by the author in Horae S. E. R. v. XL, p. 5, 1912, translated in Mitt. Münch. Ent. Ges.

In conclusion the hope is expressed that analogous cases will be carefully observed among other groups of insects and brought to light in view of the significant sidelights which such phenomena throw on the process of formation of species and on the mutual relationship of subspecific constituents.

A uniformity in application of the terms indicating various degrees of subspecific differentiation should imply a clear definition of the meaning of "species", "subspecies", "aberratio" and "morpha"; phenomena as those described above deserve a special taxonomic designation for the sake of stability and consistency of the whole system.

The European Corn Borer, Pyrausta nubilalis Hübn.: Its History and Status as a Problem in the United States.

D. J. Caffrey, Entomologist, Division of Cereal and Forage Insects, Bureau of Entomology, U. S. Department of Agriculture, Toledo, Ohio.

Eleven years ago this summer the presence of the European corn borer (*Pyrausta nubilalis* Hübn.) was first discovered on the North American continent. At that time (1917) this introduced pest was found to be causing severe damage to sweet corn in the vicinity of Boston, Mass., and to be present there throughout an area of at least 100 square miles.

In January, 1919, the insext was discovered in the vicinity of Schenectady, N. Y., and in September, 1919, separate infestations were found immediately southward of Buffalo, N. Y., and at Girard, Pa.

The summer scouting in 1921 revealed an infestation of the pest on Middle Bass Island in Lake Erie, not far from the Ohio shore. Subsequent investigations during 1921 and 1922 showed that a sparse but extensive infestation had developed throughout a narrow strip of territory comprising most of the townships bordering Lake Erie, and adjacent thereto, in the States of Michigan, Ohio, Pennsylvania, and New York.

During the late summer of 1923 a small area of infestation was discovered at Brooklyn, N. Y. Limited infestations were also found during the period from 1924 to 1926 on Staten Island, N. Y., and in scattered townships in Connecticut along the shore of Long Island Sound. Two small, separate infestations were found in the Bayonne and Jersey City sections of New Jersey during this period.

In the late season of 1926 the corn borer was found to have entered northeastern Indiana; a single specimen was found in Yellow Head Township, Kankakee County, Illinois, and a few specimens were discovered in the southwestern corner of Michigan in Berrien County. During October, 1927, a single larva was found in Goshen Township, Oldham County, Kentucky, in the valley of the Ohio River.

At the close of 1927 *P. nubilalis* was known to be present and well established throughout two large separate areas of the United States, as well as the isolated areas just described, comprising a total of approximately 110,000 square miles of territory. The first large area, which may be roughly defined as the one-generation area, includes the eastern two-thirds of Michigan; the northeastern quarter of Indiana; the northern two-thirds of Ohio; the northwestern half of Pennsylvania; the entire western, central and northern sections of New York; together with small contiguous strips in southwestern Vermont and western Massachusetts. The second large area, which may be defined as the two-generation area, comprises approximately the southern tip of Maine; the southeastern third of New

Hampshire; the eastern half of Massachusetts; practically all of Rhode Island and scattering townships along the shore line of Connecticut.

Throughout a large portion of the territory previously mentioned, *P. nubilalis* is present only in limited numbers. However, in those portions of the various infested areas where the insect was first discovered, and where it has been known to exist for several years, economic losses have occurred in limited localities. Undoubtedly the extent of economic loss has been lessened by the "clean-up" policy, or farm disposal of corn residues, practised in nearly all areas since the presence of the insect was first detected. While the clean-up, in some sections, left much to be desired from the viewpoint of thoroughness and scope during the early years when this policy was adopted, and is still deficient in the more recently invaded areas, it has resulted in greatly reducing the borer population carried over from one year to another in the corn residues and other plant debris, thus limiting the natural increase in numerical abundance of the borer and possibly restricting the distance of annual dispersion.

Economic History.

The localities where important crop losses have occurred, as a direct result of the depredations of the corn borer, may be listed briefly as north-eastern and south-eastern Michigan; north-western Ohio; western New York in the environs of Silver Creek; the vicinity of Schenectady in eastern New York; and the territory immediately north, west and south of Boston, Massachusetts.

In those areas of Michigan and Ohio, representing maximum infestation, severe economic loss caused by the European corn borer occurred for the first time during 1926. In a few cornfields of these sections the estimated crop loss to dent (field) corn and sweet corn ranged from 25 to 40 per cent in the worst-infested fields. As a result of the extensive clean-up campaign conducted during the spring of 1927, the borer population was greatly reduced in the more heavily infested sections, this clean-up being immediately reflected in reduced commercial losses in most of the localities where such losses had occurred in 1926. In general, the commercial damage by the corn borer in Ohio and Michigan during 1927 was confined to a few fields and did not exceed 5 per cent of the total crop value, except in rare cases.

In western New York a gradual increase in intensity of infestation developed from the year of its discovery until 1926, at which time the estimated commercial loss exceeded 25 per cent in many of the fields of dent corn grown for grain, in the older portion of the infested area centering around Silver Creek. In this same district the loss in sweet-corn ears grown for canning in 1926 reached about the same figure (25%). The 1927 clean-up in western New York produced a beneficial effect similar to that described for the areas to the westward, so that the infestation in the 1927 crop was greatly reduced and serious damage confined to a few fields, seldom exceeding 5 per cent of the total crop value.

The area occupied by the corn borer in eastern New York presents an economic history quite different from that of the areas previously described. Here the presence of the pest was first detected in an isolated area during the year 1919, but owing to a thorough clean-up conducted

by the New York State authorities in 1920 in addition to the prevailing system of farm practice which leads to the utilization, or destruction, of a large portion of the corn fodder and corn residues, the larval population has increased at a slower rate within the original area of infestation than in any other portion of the United States under observation. These aids in retarding the normal increase of the borer have been supplemented by the usual educational work having for its object the stimulation of clean cultural practices on the part of most of the farmers. Observations made each year in the original area of infestation in eastern New York, have been impressive in demonstrating, in general, that much smaller amounts of corn residues were left in the field than was the case in the infested areas farther west. A few indifferent growers, however, have not complied with the requirements of effective clean-up, or farm disposal, and such negligence has resulted in a very gradual increase in borer population in this area since 1921. In fact, a five-fold increase, during the period from 1921 to 1927, has been shown by the annual infestation survey. This rate of increase is less than in the other areas previously discussed and has resulted in restricting commercial losses to a low point. In 1926 and again in 1927, a few cornfields in the central district near Scotia suffered losses estimated as ranging from 5 to 15 per cent of the total crop value. Outside of this district, and except in these few fields, very little appreciable economic loss developed to date.

The economic history of the corn borer in New England is complicated by the fact that two generations develop annually in this area, and that, in addition to corn, the insect infests directly a great variety of vegetables, field crops, flowers, weeds and grass-like plants. At the time of its discovery in 1917 the corn borer was damaging severely the early sweet-corn in fields near Boston and a light infestation was observed in the more common vegetables, flowers and weeds. Although volunteer clean-up measures were instituted by property owners in 1919, supplemented by State and Federal aid, and continued on this basis until 1922, the funds available were not sufficient for conduct of a thorough general clean-up during this period. This condition permitted a very rapid increase in the intensity of infestation, so that at the close of 1922 severe losses were being sustained by the growers of sweet and field corn, in the area first found infested. Meanwhile the damage to vegetables, field crops and commercial flowers had rapidly increased and corresponding losses had been suffered by the growers of these crops.

As a result of the damage caused by the corn borer in this area, culminating in the conditions described for 1922, the State of Massachusetts promulgated a law, at the close of that year, requiring clean-up action by property owners. Since 1922 the crop losses and degree of infestation have decreased very greatly in the earlier infested portions of the Massachusetts area and in the adjoining areas of Maine and New Hampshire. The decreases have been particularly noticeable in the large and valuable areas of market-garden sweet corn where an average of 20 per cent ear infestation in 1922 had been reduced to an average of less than 5 per cent in 1927. The annual infestation survey in the cornfields of the New England area during 1927 demonstrated that the larval population had decreased approximately 90 per cent during the period of 1922 to 1927.

Similar reductions in infestation have occurred in vegetables, flowers, field crops and weeds. This reduction in the numerical abundance of the borer may be attributed principally to the clean-up laws in force, plus weather conditions adverse to the insect during a portion of this period and to the activities of the egg-parasite, *Trichogramma minutum* Riley, at critical periods.

Effective Control Measures.

Specifically this means, in infested areas, that all corn fodder, corn remnants and other plant debris from infested fields must be utilized, or destroyed, by one or more of the following methods or by a combination of such methods: 1. By feeding to livestock direct from the field, or in the form of silage, or finely cut, finely ground, or finely shredded material. 2. By plowing under *cleanly*, and deeply enough to insure that the turned-under material will not again be brought to the soil surface by later cultivation, or weathering, to act as a shelter for migrating larvae, before the moths emerge; this involves ordinary cultivation after plowing to close all large cracks and crevices on or near the soil surface. 3. By burning *completely* or exposing to sufficient heat to kill all contained larvae or pupae. This includes the poling (or cutting), raking and burning in piles, or windrows, of cornstalks and infested weeds in fields where corn is husked from the standing stalks; the burning of surplus shocks where this method of harvesting is practised; and the burning of all cornstalks used in building shelters for livestock, for thatching, windbreaks and similar purposes, as well as cornstalks stored for feeding purposes; and the burning of cornstalks along ditch banks and field borders, and portions of unprocessed corn residues left in feed lots, barnyards and similar places unless trampled deeply into manure.

Certain other control measures, promising ultimate utility, are still under intensive investigation, but have not advanced to a point where they can be assigned a definite value or recommended with an assurance of their effectiveness under the various conditions encountered in the infested areas. For example, trap crops cannot, in the light of our present knowledge, be depended upon to produce desired results, while the possible manipulation of corn varieties, and time of planting such varieties to escape serious corn borer damage, is still in the experimental stage. The same situation exists with respect to the use of imported parasites, insecticides, attrahents and repellents.

Ineffective Control Measures.

On the negative side of the scale, experiments and field observations have demonstrated that certain widely used farm practices are not effective in the suppression of the corn borer. Among such ineffective measures may be mentioned the disking of cornstalks or high corn stubble lands to small grains without previous treatment; the use of various tillage rollers, cultipackers, harrows and wide-tire tractors as agents to obtain direct kill; and pasturing with livestock. The use of trap lights, which is a very popular idea, has proved entirely ineffective. Special projects have shown that high corn stubble contains a dangerously high proportion of

the original borer population present in the plant, and that from an entomological viewpoint, the only "safe" corn stubble is that left from cornstalks cut at the ground level. It has been ascertained that a 2-inch stubble is the maximum height which can be tolerated, without additional treatment.

Special Research Projects.

Mechanical: During the progress of clean-up operations through public or private enterprise, it has become evident that while the strictly entomological information at hand is adequate to secure effective results, the application of mechanical processes in disposing of infested crop residues requires improvement in the performance of regular or special farm machinery as well as the exercise of greater skill in its manipulation on the part of the ordinary farm operator.

A noteworthy example may be cited in the instance of existing types of rakes for gathering infested trash into windrows or piles, preparatory to burning. Unless handled with skill and judgment, such rakes usually leave far too great a quantity of infested material on the soil surface and render hand-picking necessary as the only solution for completing a satisfactory clean-up. in instances where the finishing touch cannot be supplied by plowing.

Many plows found in use are unable to meet the requirement of clean plowing, even in the presence of comparatively short stubble or small amounts of trash, while in other instances the possession of adequate equipment is often nullified by improper adjustment of the plow or its attachements, or by carelessness on the part of the operator.

The necessity of cutting corn as close to the ground as possible, when the farm practice involves the cutting of corn, has been previously mentioned. This problem is engaging the attention of the agricultural engineers, and tests of various low-cutting devices, for attachment to corn binders, are now under way.

Burning operations, by machine or otherwise, are found to involve problems of combustion which have suggested an important research project to determine the influences responsible for the death, or the survival, of the corn borer when contained in cornstalks subjected to high degrees of heat for short periods, but which are not consumed by the flames.

These mechanical problems, and others of a similar nature, are being made the objects of extensive research by the agricultural engineers in cooperation with the entomologists.

Agronomic: With the successful operation of farm machinery designed to cut corn close to the ground, is involved the important factor of erectness in the corn plant at the time of harvest, to insure that the quantity of loose fodder and other plant debris left on the ground as "leakage" be reduced to a minimum. Since the agronomists are already engaged in the attempt to produce corn characterized by rigid or stiff stalks, as a factor in tolerance to corn-borer attack, this endeavor has received increased impetus.

In many of the fields in the infested area, where spring plowing is the most practical method of completing a satisfactory clean-up, the soil

conditions are such as practically to prohibit this operation, without seriously interfering with the prevailing crop rotation. (This condition is particularly true in the instance of corn lands intended for disking to small grain in the spring.) This problem has emphasized the necessity of concentration upon research regarding such crop rotations as will permit plowing as a finishing operation to corn lands, under corn borer conditions.

The fact that late planted corn usually is infested to a lesser degree than early planted corn and that certain varieties of corn are more resistant to severe corn-borer injury than others, though none have been demonstrated to be immune, has led to an attempt to develop varieties of corn better adapted to corn-borer conditions or which may be planted later in the season than the normal time, when and where necessary, with due regard to profitable yields.

These agronomic problems, and others of a similar nature, are being made the subjects of extensive research by the agronomists in cooperation with the entomologists.

Natural Enemies: The possibility of procuring a significant control through the natural enemies of the pest, particularly its insect parasites, has commanded keen interest. Great emphasis is being placed, therefore, upon this phase of the research activities.

Studies of the native insect parasites of the corn borer in the United States have shown that less than one per cent of the total borer population, on an average, was being destroyed by the activities of the native parasites. Whether these native parasites will exhibit an increasing tendency to adopt the introduced European corn borer as a host, remains to be determined.

Since investigation of the native parasites soon demonstrated that such species were of little consequence as natural checks, the next logical step was to import insect parasites from the original home of the corn borer in Europe and Asia. In taking this action the most cordial cooperation was given by the entomologists in Europe and Asia and many thanks are due them for the aid extended.

A total of 12 species, consisting of a total of approximately 2,500,000 individual parasites, have been either imported or bred in the laboratory from imported material, and liberated at strategic points in the United States. Seven of these species have been recovered in the field, under circumstances indicating their permanent establishment.

The details regarding the collection, rearing, breeding, liberation and recovery of these imported species involve many complicated problems which must be solved by continued research. It is proposed to extend these research activities, at home and abroad, looking toward the importation of all desirable parasitic species, supplemented by adequate breeding operations in the laboratory.

Field Infestation Surveys: As a part of the investigations to determine the status of the European corn borer as a pest of corn, and the annual progress of infestation, surveys of field conditions are made each year in all infested areas. Similar surveys are made before and after the fields have been cleaned-up, or the ordinary methods of farm disposal applied to determine the relative effectiveness of different control measures.

These surveys are designed primarily to supply information regarding the percentage of plants infested and the larval population in each field examined. The data obtained permit an accurate comparison of conditions within each portion of the infested areas from year to year and an evaluation of the effectiveness of clean-up campaigns or other control measures. Such surveys are accompanied by fields studies to determine the character and extent of crop losses, particularly the exact relationship between larval population and damage to the corn plant involving both direct and indirect loss in the production of grain.

B e h a v i o r i s t i c S t u d i e s : As an aid in interpreting results of field observations and control experiments it has been found important to conduct several projects having for their object a study of the behavior of the larvae and adults of the corn borer.

Among the more important of these projects may be mentioned a detailed study to determine the factors affecting larval survival. It is well known that a very high proportion of young larvae hatching from the eggs perish before reaching full growth through their inability to become permanently established in the plant. The percentage of larval establishment, and the resultant itensity of infestation, apparently vary according to prevailing weather conditions, character and condition of the host plant and other influences as yet not fully understood. Since this larval survival is of such great importance in affecting ultimate larval population and must be taken into consideration when defining the results of field and laboratory experiments, a correct explanation of all limiting influences is of great economic importance.

The behavior of corn-borer larvae when plowed under and of the resulting moths, if any, the reaction of larvae when contained in plant material immersed or floating in water, flight habits of adults, and similar studies with a practical application are being given careful attention.

C h e m o t r o p i s m : In an attempt to aid in the control of the corn borer through the use of baits or traps, an extensive investigation is under way, in cooperation with the B o y c e - T h o m p s o n I n s t i t u t e of Plant Research, with the object of isolating or developing attrahent or repellent substances which can be employed in field operations. Encouraging progress has been made in this project and it is hoped that this investigation may develop measures which will aid the grower to protect his crops.

I n s e c t i c i d e s : Although the application of insecticides has proved ineffective in protecting growing corn from injury by *P. nubilalis* in all experiments conducted up to the present time, this project is being continued with vigor and involves a general study of the physiology of the corn borer and the corn plant.

While none of the insecticidal materials tested, to date, can be recommended for practical use in combating the corn borer, the objectives sought, and the results secured, appear to be of sufficient importance to justify a continuance of the experiments now in progress and an intensification of the effort to develop effective insecticides.

International Cooperation.

Outstanding among the various encouraging features of the European corn borer investigation have been the inspiration derived from the splendid cooperation, enthusiastic personal contacts, genuine sympathy and practical support enjoyed between the Dominion and Provincial Entomologists and ourselves. The extensive scope and the international character of the proposition were quickly realized and every opportunity has been utilized to the utmost for the mutual exchange of significant information marking every advance toward a possible ultimate solution of the problem.

Attitude of the Public regarding the Corn-Borer-Problem.

A discussion of the status of the European corn borer in the United States would be incomplete without an attempt to analyze the present attitude of the public with regard to this insect and the problem it presents to agriculture and allied industries.

In practically all localities where the insect has become sufficiently numerous to cause appreciable economic damage there exists a prevailing recognition of the fact that the corn borer is a pest of prime importance which must be combated through the recommended methods of control and quarantine. Unfortunately, however, in some localities where the borer is present, but has not increased in numerical abundance to a point where the menace imposed by its presence can be appreciated by direct observation, there exists a sentiment on the part of the less intelligent individuals that the campaign to combat the borer is unnecessary, and a disposition to await the possible development of severe economic loss before adopting adequate measures of control. This same habit of thought, it may be recalled, has been evident in the instance of other introduced insect pests, notably the gypsy moth, cotton-boll weevil and others, with disastrous consequences which are now a matter of history.

Despite the abundant evidence of its ability as an enemy of agriculture presented by the ravages of the corn borer in New England and just across Lake Erie in Ontario, Canada, as well as by destructive outbreaks in the principal corn-growing areas of Europe, a disposition persists to question the status of the corn borer as an important pest, and there exists in some quarters a failure to recognize the fact that a persistent program of control, instituted when the presence of the insect was first delected, has unquestionably led to a great reduction in the intensity of infestation and has limited the normal rate of increase. Apparently we must await the actual development of serious infestation before the possibilities of damage by the pest will be fully realized by all interests concerned in a given locality. Attempts to forecast the areas in which the corn-borer will accumulate in destructive numbers, formal reports issued without sufficient field experience to substantiate the data presented, and lurid newspaper articles, have served to complicate and obscure the real issue of observing adequate precautions and that it is necessary to combat this dangerous insect by direct action.

An interesting development in connection with the enforcement of clean-up regulations has been the attitude and practice of the courts, and certain members of the legal profession, in dealing with entomological

questions. During the progress of various injunction proceedings instituted by those opposed to regulatory measures the fact has been brought out quite sharply that the opinion of a farmer, or a lawyer, relating to entomological questions is considered to be as reliable as the opinion of a trained entomologist. This have even extended to the widespread belief that the "so-called" European corn borer has always existed in North America and is, in fact, the same as other native species of boring lepidoptera possessing superficially the same appearance or causing similar damage to its host plant. Decisions have been rendered by the courts, in certain of such cases, which were totally at variance with the facts and in utter disregard of the seriousness of the situation to the public at large.

Conclusions.

From the viewpoint of agricultural and allied interests it may be concluded that research and field control activities have demonstrated the feasibility of retarding the normal increase and dispersion of the European corn borer, and restricting its abundance below a point where serious commercial damage can occur, by adhering to the recommended clean farming practices. Furthermore, investigations pertaining to cultural practices, agronomy, agricultural engineering, natural enemies, insecticides and general physiology promise to improve the methods of control now in use and add to their field of application. It would appear that an intelligent utilization of the information now available and a proper spirit of cooperation on the part of those most interested in the problem, should permit the farmers to grow, corn profitably despite the presence of the European corn borer.

A Protest against the Use of Abbreviations in Original Descriptions.

J. E. Collin, President Ent. Soc. London.

For some years past there has been a growing tendency, at any rate among students of Diptera, to make use of abbreviations in their descriptions of species. This habit appears to have originated in attempts to simplify references to the veins and cells of an insect's wing. Desvoidy in 1830 used a system of referring to the veins by Roman Capital letters and the cells (beginning at the base of the wing and working outwards) by small Greek letters in combination with the Roman Capitals. This system received no support and it was not until Comstock & Needham studied the homologies of the different veins in all orders of insects and suggested the use of a much more natural system of nomenclature, that reference to the veins and cells by letters and numerals came into more general use. If the matter had gone no further there would have been little cause for complaint, but a gradual extension of the principle to the different parts of an insect's anatomy has been creeping into entomological literature, especially among German taxonomists; but it has been left to Charles H. T. Townsend to carry the principle still further and to produce the most amazing "descriptions" that have ever been published.

It is, of course, a primary necessity for any entomologist to learn the terms by which the different parts of an insect are referred to in descriptions. This is not an easy task and has been made additionally difficult by the lack of uniformity in the use of terms. This difficulty is only increased by the use of terms which are not (as far as possible) self explanatory.

It may reasonably be argued that there should be no objection to the use of such a system as that of Comstock & Needham for wing venation; it can matter very little whether you learn to call a vein the "subcostal" or "R_1", the "radial" or "R_{2+3}" so long as the identity of the particular vein is made clear. It must be remembered, however, that terms such as "subcostal", "discal", "postical", "anal" do give some aid to the memory as to the position of the veins, and if abbreviations are used in their place it is still necessary to learn the terms to which the abbreviations apply. The same argument applies to the terms used for most of the different parts and specialized bristles of insects. "Head", "proboscis", "hypopygium", "prosternum", "ocellar bristle", "fronto-orbital bristle", "posthumeral bristle" all give to an educated person an idea of what is indicated without mental effort, but to realize what "h", "p",

"hy", "pstnr", "ocs", "fro", "ph" mean imposes a strain on the memory which is as irritating as it is unnecessary.

There are at least three papers by Townsend in which abbreviations have been used not only for most of the different parts and specialized bristles of the insects described, but also for descriptive terms such as angular, geniculate, pubescent, pectinate, plumose, proclinate, etc., and even for phrases like "bristled only at the base". These papers give descriptions! of Muscoid flies in what practically amounts to a "code" and are indecipherable without a key. The first paper was published in "Supplementa Entomologica" xiv., 1926, where a long list of "Abbreviations of Muscoid characters" is given and where the author states that in the future all Muscoid descriptions and synopses published by him will be abbreviated according to that list. The following is a copy of the description of a new genus in that paper:

Aphantorhaphopsis n. gen. (Genotype *Aphantorhaphopsis orientalis* n. sp.) Differs from *Aphantorhapha* as follows: — Vx eq anx; 3 an ♂ 3 x 2 an; 2 ar only 2 x as long as wide; vr ♂ $^1/_3$ hw; frl ♂ 2 = pfrw, eql; pfcl narrowed nearly to a line below; ch little over $^1/_5$ el ♂ ; cb not $^1/_4$ ww from hwm; M_3 in middle; lsc C1 less than ½ preceding; ab oval.

The second paper is a longer one in the "Revista do Museu Paulista xv. 1927"; again a list of abbreviations is given, and it is amazing to find that in some cases the meaning of a certain abbreviation in the first paper is here represented by a different abbreviation.

In the third paper (Wien. Ent. Zeitung xliv, 1928) a list of abbreviations "additional to those already given" is printed with no reference to where the other abbreviations (freely used in this third paper) are to be found.

It should be the object of anyone publishing an entomological description to make it easy for other entomologists to recognize the species described. Townsend, by his use of abbreviations, has exercised a fiendish ingenuity in making the recognition of the genera and species he has attempted to describe as difficult as possible, and in the interests of Entomological Science I feel it necessary to lodge a protest.

I purposely confine my protest to the use of abbreviations in original descriptions. There may well be publications, such as pocket handbooks, where abbreviations would be useful in helping to keep the work as small as possible, or some monographs where a certain character is referred to in almost every description and might well be abbreviated, while of course in private notes and card indexes one is entitled to use any form of shorthand or other system of abbreviations one may chose, but in all original descriptions, which should aim at quickly producing to the reader a mental picture of the object described, abbreviations of any sort should be avoided, and I urge the Commission on Zoological Nomenclature to consider the advisability of prohibiting their use in future work of such a nature.

Resolution. — That the use of abbreviations in original descriptions imposes an unnecessary burden upon taxonomists and should be prohibited.

Discussion.

A. L. Melander: — I regret to see the extreme use of abbreviation as published by Townsend in the current issue of the New York Entomological Society. The same abbreviation is used in many senses and must be solved by its position in the description. The abbreviation *a* may stand for *anterior,* but *a* may also stand for *antenna* if at the beginning of the description, or *alula* if in the middle, or possibly *anus* if at the tail end.

J. M. Aldrich: — I sympathize entirely with the speaker's protest against the excessive use of abbreviations by Dr. Townsend. The first use of them as I recall was in Insecutor Inscitiae Menstruus, some three years ago, where Dr. Townsend has an article on "New Nearctic Muscoidea"; he has also printed another on "New Philippine Muscoidea" in the Philippine Journal of Science. Thus there appears to be 5 of his papers in this class.

Probably the increased cost of composition will be a deterrent to the continued use of this style, as in one case the editor told me that his printer, after one experience, informed him that the cost of setting type on such an article in the future would be double that of ordinary printing. According to Dr. Townsend's latest article he is having greatly increased difficulty in getting editors to accept his publications.

C. W. Stiles: — Raised the question as to whether these formulae are definitions in case the author gives no key to the abbreviations. If not definitions or indications or descriptions, the names are nomina nuda, hence not subject to the law of priority.

L. B. Prout: — The question raised by Dr. Stiles as to the validity, under the International Code, of publications in Dr. Townsend's system of shorthand can, in my opinion, be answered by discriminating sharply between those papers which publish a key to the abbreviations, or alternatively a bibliographic reference to such a key, and those which provide no such elucidation. It would be very interesting if the International Commission could give an opinion of the requirements of a definition in words, but it seems pretty clear that a "definition" in what are to the ordinary reader mere hieroglyphics does not fulfil legitimate requirements, whereas we have no possible machinery for ruling out any explained abbreviations, however irritating they may be.

J. E. Collin: — In winding up the discussion, said that he particularly wished to emphasize the trouble which such descriptions would cause to taxonomists. Their work was sufficiently difficult without any additional burden. The question as to whether the names had complied with the Rules of Nomenclature he left to those more competent to deal with such points.

It was interesting to note that the typist who had typed his paper, while experiencing no difficulty in deciphering the main part of his MS. made numerous mistakes in copying Townsend's sample description. Proof reading of such descriptions would therefore certainly be a difficult and expensive matter.

Some Problems in the Control of Underground Insects.*)

J. W. McColloch, Kansas Agricultural Experiment Station, Manhattan, Kansas, and W. P. Hayes, University of Illinois.

The control of insect pests attacking the underground parts of plants is one of the oldest and most difficult problems with which the economic entomologist has had to contend. Progress in the development of control measures has been slow and at the present time there are no satisfactory measures available for many of the most important pests. There are many factors responsible for this situation. The large number of insect species concerned, their diverse habits, and their protected environment present many difficult problems. In addition, the control of subterranean insects involves certain manipulations of the soil which in turn influence its condition and the plants grown upon it. Thus the problem extends beyond the field of entomology and calls for cooperative investigations with soil technologists, agronomists, chemists, and plant physiologists.

In a previous paper, the writers (1922) briefly outlined some of the problems connected with the development of control measures for soil-inhabiting insects. The present paper discusses more in detail the important problems involved in such a study and indicates something of the complexity of the investigations. Space does not permit of a comprehensive review of the literature and only such citations are made as illustrate the points under consideration.

INJURIOUS INSECTS OF THE SOIL.

The soil is the home of a vast series of insect species, either during their entire life or some portion of it. They utilize the soil for shelter, protection, food, moisture, air, heat, materials of abode, and as an avenue of travel. Cameron (1913) defines the term soil insect as comprising "all insects which at one time or another in the course of their development from the egg to the imago spend some stage or stages of their life histories either on or beneath the surface of the soil".

There are hundreds of injurious insect species, representative of nearly all orders, which might be designated as soil insects. Obviously, it is impossible to enumerate all of the injurious species associated with the soil environment. The true white grubs *(Phyllophaga)*, for example, are represented by over 100 species in the United States, while there are many additional species in the closely related genera *Anomala, Ligyrus, Cotinis,*

*) Contribution No. 369, from the Entomological Laboratory, Kansas State Agricultural College, and Contribution No. 157, from the Entomological Laboratory, University of Illinois.

Cotalpa and *Ochrosidia.* A brief review, therefore, is given of the insect orders, indicating the more important injurious groups which utilize the soil.

Thysanura and Collembola. — Numerous species of these orders spend their entire life in the soil and feed upon plant material.

Orthoptera. — This order is best represented by the grasshoppers *(Locustidae)*, which deposit their eggs in the soil, and the field crickets *(Gryllinae)* and mole crickets *(Gryllotalpinae)*, many of which spend much of their life history underground.

Isoptera. — White ants *(Termitidae)* are representative of this order that make their home in the soil.

Homoptera. — The principal subterranean pests in this order are the *Cicadidae* and the root-feeding species of the *Aphididae* and *Coccidae.*

Lepidoptera. — Numerous species of this large order live in the soil for varying periods of their life cycle. In many cases only pupation occurs in the soil, the other stages being above ground. This happens among many species of *Notodontidae, Geometridae, Sphingidae* and *Noctuidae.* The larvae of the sod webworm *(Crambidae)* live in nests constructed of bits of earth. Many *Noctuidae*, especially the cutworms, spend much of the larval period in the ground, and in the case of the pale western cutworm *(Porosagrotis orthogonia* Morr.), eggs are deposited on the soil and the entire larval period is spent below the surface.

Diptera. — The maggots and pupae of many families of Diptera are found in the soil, and especially that rich in organic matter. Such families as *Tipulidae, Tabanidae, Sarcophagidae, Muscidae* and *Anthomyiidae* are well represented by injurious species. In the case of *Oestridae*, the maggots are parasitic on mammals, but leave the host to pupate on or in the ground.

Coleoptera. — This order contains many injurious species closely associated with the soil environment. Nearly all the members of the families *Scarabaeidae, Elateridae, Tenebrionidae* and *Meloidae* spend the egg, larval, pupal and part of the adult stage in the ground. Numerous species of other families are well represented in the fauna.

Hymenoptera. — The ants, bees and wasps present many interesting groups of soil-inhabiting insects. Of these, the ants probably are the most important injurious group.

GENERAL CONSIDERATION OF CONTROL MEASURES.

The soil is a complex of many factors which separately and conjunctively are of vital importance to insect life and must be studied in connection with any investigation of underground insects and their control. Fleming (1925) emphasizes this point in the following statement: "Soil is a heterogeneous mixture of solids, gases and liquids inhabited by living organisms that serves for the support and sustenance of plants. It is composed of mineral debris from rock disintegration, degradation and decomposition; organic matter from the decomposition of animal and vegetable tissues; soil air always richer in carbon dioxide, nitrogen and water vapor than the atmosphere above the soil; living micro-organisms and macro-organisms with the products of their metabolism; and soil moisture, a solu-

tion of all the soluble components of the soil and the natural medium for plants. The soil processes are, therefore, physical, chemical and biological; they are always interdependent and never exactly the same. Each of these processes is unstable and tending towards stability so that the soil is essentially dynamic. The bacteria, fungi and protozoa react directly to their environment and vary in numbers and activity with the favorableness or adversity of their surroundings. The soil moisture tends to become saturated with the different products of plant and animal metabolism, with humus, with mineral salts, and with the soil atmosphere and necessarily differs in saturation and composition with the change in the soil components. In brief, soil is not a stable inert material; soil is the unstable resultant of physical, chemical and biological forces." Insects also react directly to their environment and their numbers, and activities are influenced by the conditions of their surroundings.

Numerous measures have been advocated for the control of soil-inhabiting insects. For the purpose of discussion in this paper, these measures may be classed as cultural methods, crop rotations, use of insecticides, use of repellents, use of fertilizers, soil surveys and miscellaneous methods. It is evident that an investigation of any of these measures involves more than a study of the effect upon the insect. The reaction of the treatment upon the physical, chemical and biological factors must also be studied and this requires cooperative investigations with workers in many fields of science. Insect control measures should not be recommended simply because they control the pest. Subsequent studies may show that they seriously injure the constituency and productivity of the soil. Investigations of control measures for underground insects, therefore, should be along the following general lines:

1. Effectiveness against the insect;
2. Effect on the physical properties of the soil;
3. Effect on the chemical properties of the soil;
4. Effect on different types of vegetation;
5. Effect on other biological factors;
6. Cost of treatment.

There are many factors which must be taken into consideration in a study of underground control measures. In general, it may be stated that the insect, the crop and the soil type determine the methods to be applied. It is obvious that insects attacking the roots of cereals cannot be controlled in the same manner as those attacking lawns, gardens and ornamentals. In the former case, reliance must be placed largely on cultural methods and cropping systems, while in the latter case it is often practical to apply chemicals or other expensive measures to secure control.

CULTURAL MEASURES.

The control of many insects attacking the underground parts of cereal crops necessarily must be by cultural methods. These measures involve such practices as plowing, listing, disking, harrowing, cultivating, summer fallowing, and time and method of planting. Such operations require a thorough knowledge of the soil and the effect of these measures on it. Soils respond differently under cultivation, and the successful manipulation of the ground

is dependent on a knowledge of the important factors involved. A recommendation to plow and work the soil might be practical in the eastern United States, but it might prove disastrous in the Great Plains area where the soil is subject to blowing. The utilization of cultural measures for insect control, therefore, requires an analysis of the existing conditions of the soil and a determination of the changes to be effected. These are problems for the agronomist and soil specialist, as well as the entomologist, and their cooperation should be enlisted.

The influence of cultural methods in insect control can be illustrated by certain studies made by the writers in Kansas. While investigating an outbreak of the kafir ant *(Solenopsis molesta* Say) in the sorghum fields of Southern Kansas in 1911, it was noted that in every case the injury was more pronounced in listed fields. Where the crop had been surface planted, very little damage occurred, and subsequent studies have borne out these observations.

A somewhat similar case was encountered in the corn experiments on the Kansas Agricultural Experiment Station farm at Manhattan. In 1924, tests involving three methods of planting corn were conducted on land that proved to be heavily infested with wireworms *(Melanotus sp.).* An examination of the plats planted April 11 showed that there was a marked difference in the wireworm damage with relation to the method of planting. Forty-five percent of the hills in the surface-planted plat had been injured, the open furrow plat had 19 percent of the hills infested, while the listed corn showed an infestation of only nine percent.

CROP ROTATION.

Crop rotation is one of the more generally recommended control measures for many soil-inhabiting insects. This is especially true in the case of white grubs *(Phyllophaga),* western corn root worm *(Diabrotica longicornis* Say), and the corn root aphid *(Aphis maidi-radicis* Forbes). Rotation, however, cannot be practised successfully unless a thorough study is made of soil conditions and suitable crops. A rotation which is effective in insect control in one section may be agronomically unsound in another. It is generally recognized that all crops do not grow equally well upon the same soil. Every crop is adapted to make its best growth on a particular soil and under particular climatic conditions. Crop rotation for the control of insects, therefore, becomes a local problem and should be developed through cooperative studies by entomologists, agronomists, and soil specialists.

This plan is being followed at the Kansas Agricultural Experiment Station. The Agronomy Department maintains a large series of one-tenth acre plots on which various rotations of corn, wheat, oats, alfalfa and sweet clover are practised. As a check against these plots, there is another series on which these crops are grown continuously year after year. The Department of Entomology has been utilizing these plots in a study of the effect of various rotations on insect damage. While this work has been under way only a few years, many interesting results are being obtained. Wireworm damage, for example, has been greatest to corn following oats and least where corn has been grown continuously on the same

ground. On the other hand, damage by the western corn root worm has been greatest on continuously cropped land.

In order to maintain a continuous pasture in some dairy sections of Kansas, it is a common practice to grow Sudan grass during the summer and follow this with rye in the autumn. Several such fields have been under observation during recent years and it has been found that the adults of the southern corn root worm *(Diabrotica duodecim-punctata* Fab.) and one of the smaller click beetles *(Drasterius elegans* Fab.) are attracted to the Sudan grass in large numbers for egg deposition. When the Sudan grass is plowed under and the land sown to rye, the larvae of these insects attack the roots of the young plants and destroy the stand.

Numerous other examples of the relation between soil insects and crop diversification might be cited. Every community has its particular problems relative to cropping systems and insect depredations which call for cooperative investigations on the part of agronomists and entomologists. The failure of the economic entomologist to recognize the necessity of a fundamental study of the agronomic phases in his recommendations and of the agronomist to consider the part insects play has resulted in considerable confusion. As Fernald (1921) points out, the entire subject of crop rotations which are satisfactory from the standpoint of agriculture and also correct when insect problems are considered is still in a far from settled condition, and needs prolonged investigation.

USE OF SOIL INSECTICIDES.

A considerable amount of work has been done by various investigators relating to the use of insecticides for the control of underground insects. Several writers, including Davis (1920) and Fleming (1925), have outlined the history of the development of soil insecticides and have given brief resumés of the literature on the subject. Marion (1877) was one of the first to utilize this method of control when he advocated the use of carbon bisulphide against the grape phylloxera *(Phylloxera vastatrix Plan.)* in France. About ten years later, Alwood (1888) experimented with kerosene emulsion on the grubs of *Cotinis nitida* L. with some degree of success. The recent introduction of the Japanese beetle *(Popillia japonica* Newm.) into the United States has stimulated research along this line and a large amount of work is now being conducted in many localities.

Soil insecticides may be used as fumigants, contact insecticides, poison baits, or direct poisons. The list of materials which have been suggested for use against underground insects is extensive, and it is necessary to mention only some of the more common ones, such as carbon bisulphide, sodium cyanide, calcium cyanide, corrosive sublimate, paradichlorobenzene, naphthalene, sulphur, carbon tetrachloride, kerosene emulsion and various arsenicals. These are all chemicals which undoubtedly must effect the physical, chemical and biological properties of the soil. In the earlier investigations very little attention was paid to the effect of these chemicals on the soil, and there are many questions which must be answered before such materials can be recommended for general use. What changes take place in the structure, texture, composition, and organic matter of the soil? How do these chemicals affect the micro-organisms, such as the protozoa

and the nitrifying bacteria? Is there an accumulative effect through repeated applications? These and many other problems tax the resources of the entomologist and require cooperative investigations with soil specialists, chemists, bacteriologists, agronomists, and plant physiologists.

Komp (1920), in outlining the problems connected with a study of soil fumigation with carbon bisulphide, says that it is necessary to determine the maximum dosage non-injurious to the plant, the minimum dosage lethal to the insect, and the influence of temperature and moisture conditions upon the effectiveness of the fumigation. De Ong (1927), writing of sodium cyanide, states that (1) a definite ratio must be established between the minimum point of toxicity to the insects and the maximum dosage which is safe for germinating seeds and plants, and (2) a study must be made of the physical and chemical action of the gas in the soil, the rate and extent of diffusion and absorption by soil water, the absorption of the gas by soil particles, and its decomposition by certain soil constituents. Fleming (1925) has pointed out that in a study of soil insecticides it is necessary to consider the chemical and physical properties of the compounds, the physical, chemical and biological processes of the soil, the individuality of the insect, and the individuality of the plant species.

The Kansas Agricultural Experiment Station recently has inaugurated a comprehensive study of the use of soil insecticides. This work has been underway only one year and consequently the results thus far obtained are only tentative. It seems appropriate, however, to discuss briefly the methods used and certain results obtained, since they indicate something of the complexity of the problems involved. An attempt is being made in connection with this investigation to determine the effect of each insecticide on all the various physical, chemical and biological properties of the soil. The work is being conducted in the field, in flower pots and in the soils laboratory. The field work consists of a series of one one-thousandth acre plots, each of which has been treated with a soil insecticide applied according to a recommended method. Various plants such as corn, sorghums, wheat, beans, peas, asters, and tomatoes are being grown on the plots. Studies are being made of the effect of the treatment on germination, development of root system and rate of growth of the crops and also upon the various properties of the soil. The first year's results show that plants grown on soils treated with various arsenates, sodium cyanide and paradichlorobenzene were stunted and in the case of the arsenates, the root systems were weakened. It has been impossible to grow beans on the plots treated with calcium arsenate, and corn, sorghums and wheat showed a marked tendency to lodge and break over. Sodium cyanide changed the constituency of the soil from a brown silt loam to a white alkali soil. This material also caused the soil to flocculate and run together after a rein. The plots were planted again this year and it is apparent that there is a residual effect, especially on the plots treated with arsenicals, sodium cyanide and paradichlorobenzene. Certain of these results are in accord with those of Morris and Swingle (1927), who found that the incorporation of arsenical compounds in the soil is a dangerous practice, and may cause considerable injury as the concentration of arsenic increases.

The flower pot work consists of treating the soil with definite amounts of different insecticides and determining the minimum dosage lethal to the insects and the maximum amount that the plants can stand. By using pots, it is possible to secure more uniform conditions for making a careful study of the effect of the chemical on germination, root development, rate of growth, and ratio of roots to tops. Definite numbers of insects can be introduced into the soil and the effect of the insecticide determined. The pot work also makes it possible to check the results obtained in the field plots.

In the soils laboratory, careful studies are being made on the effect of different insecticides on the physical and chemical properties of the soil. Particular attention is being paid to such properties as water holding capacity, rise of capillary water, percolation of water, flocculation, movement of air, evaporation, changes in the soil solution, and effect on microorganisms. The experiments along this line are still in the preliminary state, but they have progressed far enough to show the importance of such studies.

REPELLENTS.

The use of repellents frequently has been recommended for the prevention of injury by soil-infesting insects. Their use has been advocated for the protection of germinating seeds, for the prevention of injury to the roots, and as a means of preventing invasion of the soil. Numerous substances have been recommended as repelling agents, including such materials as crude carbolic acid, turpentine, naphthalene, paradichlorobenzene, creosote, coal tar, lemon oil, oil of tansy and various petroleum products.

Three methods of applying repellents are recognized: (1) dipping or soaking the seed in a repellent agent; (2) mixing the repellent with some fertilizer and sowing with the seed; and (3) applying the repellent to the surface of the ground. The first method is generally advocated in the case of injury to germinating seeds by wireworms, seed maggots, and ants. The second method has been used to prevent injury by the corn root aphid (*Aphis maidi-radicis* Forbes). Forbes (1915) recommends treating bonemeal with oil of tansy and placing this mixture in the fertilizer box to be dropped with the grain. The third method has been recommended as a means of preventing invasion of the soil by certain insects for egg deposition. Marie (1926) reports that sawdust saturated with kerosene, containing two percent phenol, and scattered on the soil repelled adults of *Melolontha melolontha* L., but injured certain plants. He also found that crude naphthalene powder used at the rate of 30 grams per square meter at the beginning of oviposition and again two weeks later was effective against this species. This material, however, affected the taste of early legumes.

While the use of repellents has long been advocated, the conflicting results which have been obtained indicate that there is opportunity here for investigational work. A summary of the experimental work indicates that no satisfactory repellent has been found which can be depended upon under varying conditions existing in the soil. The investigations connected with the use of repellents must be along two general lines:

(1) the development of a repellent that is objectionable to the insect, and (2) the influence of soil conditions on the effect of the repellent against the insect and on the germination of the seed.

FERTILIZERS.

The use of various fertilizers, such as kainit, lime and nitrate of soda, frequently has been recommended for the control of underground insects. In most cases, the principal benefit has been that of stimulating plant growth, thus enabling them to overcome a moderate amount of injury. Under certain conditions, fertilizers may have a place in insect control. Barnyard manure is considered an excellent fertilizer and is used extensively in many areas for soil improvement. Many insects are attracted to land enriched with this material and in some cases it has been necessary to change to commercial fertilizers. The green June beetle *(Cotinis nitida* L.) and the muck beetles *(Ligyrus)* are known to prefer soils heavily fertilized with animal manure. Injury to corn, beans, and peas by the seed corn maggot *(Pegomyia fusciceps* Zett.) is most frequent in fields where manure recently has been plowed under. The writers have noted that the application of barnyard manure to lawns in Kansas usually results in excessive damage by certain species of white grubs. Preliminary experiments indicate that much of this damage can be avoided by resorting to the use of some commercial fertilizer, such as ammonia sulphate.

SOIL SURVEYS.

The possibility of affecting insect control through the knowledge gained by the use of soil surveys is suggested by the fact that certain underground pests are most destructive on definite soil types. Anderson (1920) reports that the abundance of the slender wireworm *(Horistonotus uhleri* Horn) on the light, sandy soils of certain areas in South Carolina made it necessary to abandon or "rest" the land. The distribution of this insect is closely related to light, sandy soils which do not retain moisture, and Thomas (1911) states that land subject to infestation by this wireworm can be detected by walking over it.

Soils rich in humus or organic matter are attractive to a number of insects. The green June beetle, root maggots, and wireworms are frequently mentioned in literature as being particularly abundant in such soils. Low, heavy, poorly drained areas harbor several species of wireworms injurious to corn and in some regions corn cannot be produced on such land.

It is generally recognized that the grape phylloxera *(Phylloxera vastatrix* Plan.) is seldom injurious on sandy soils. According to Nougaret and Lapham (1928) sandy soils foster immunity in direct ratio to the proportion of silicate sand which they contain. Sand of a different nature, as calcareous debris, broken up into find particles, is subject to more or less cementation and does not act like silicate sand in obstructing phylloxera propagation. Soils containing 60% of pure silicate sand are recognized as fostering immunity. These authors made a study of phylloxera infestations in California as related to soil types, and found a close correlation. The adobe soils of the Porterville series, which are of heavy texture and compact structure, are favorable to widespread infestation,

while the Madera, Oakley and Fresno sands and the Fresno sandy loam were free of phylloxera infestation. Various degrees of infestation were found in intermediate soil types.

MISCELLANEOUS CONTROL MEASURES.

Various control measures are advocated from time to time which involve a knowledge of soil conditions and the effect which these measures will have on the ground. The pasturing of hogs in fields heavily infested with white grubs has been recommended by Davis (1922). Chittenden and Fink (1922) describe several methods of trapping the grubs of the green June beetle. Strickland (1927) suggests somewhat heavier seeding of crops on land subject to injury by wireworms. Under this category might be mentioned the dynamiting of the soil suggested by Cotton (1918) to destroy white grubs, the use of tile drains as recommended by Hyslop (1915) for the control of certain species of wireworms, and irrigation as advocated by Parker (1915) against the sugar-beet root-louse (*Pemphigus betae* Doane).

SUMMARY AND CONCLUSIONS.

In conclusion, the writers desire to emphasize that this discussion is a general presentation of some of the problems to be considered in the development of control measures for underground insects. No attempt has been made to cover the entire field nor to make an extensive review of the literature. It has been the purpose rather to emphasize the complexity of the problems and the need for cooperative work between entomologists, agronomists, soil technologists, chemists and others. The problems in the development of control measures are unlimited and are of the greatest fundamental importance to the progress of agriculture.

Literature.

1. Alwood, W. B. — 1888. Kerosene Emulsion as a Remedy for White Grubs; in Insect Life, 1. pp. 48—50.
2. Anderson, G. M. — 1920. The Slender Wireworm, its Relation to Soils; in S. C. Agri. Exp. Sta., Bull. 204, pp. 3—14.
3. Cameron, A. E. — 1913. General Survey of the Insect Fauna of the Soil within a Limited Area near Manchester. A Consideration of the Relationships between Soil Insects and the Physical Conditions of their Habitat; in Journ. Econ. Biol., 8, pp. 159—204.
4. Chittenden, F. H. and Fink, D. E. — 1922. The Green June Beetle; in U. S. Dept. Agri.., Bull. 891, pp. 1—52.
5. Cotton, R. T. — 1918. Experimental Work on the Control of the White Grubs of Porto Rico; in Journ. Dept. Agri., Porto Rico. 2, pp. 1—18.
6. Davis, J. J. — 1920. Miscellaneous Soil Insecticide Tests; in Soil Science, 10, pp. 61—75.
7. Davis, J. J. — 1922. Common White Grubs; in U. S. Dept. Agri. Farmers' Bull., 940, pp. 3—30.
8. De Ong, E. R. — 1917. Hydrocyanic Acid Gas as a Soil Fumigant; in Journ. Agri. Res. 11, pp. 421—436.
9. Fernald, H. T. — 1921. Applied Entomology; McGraw-Hill Book Co. 386 pp.
10. Fleming, W. E. — 1925. The Comparative Value of Carbon Bisulfide and other Organic Compounds as Soil Insecticides for Control of the Japanese Beetle; in N. J. Agri. Exp. Sta. Bull., 410, pp. 2—29.
11. Forbes, S. A. — 1915. Recent Illinois Work on the Corn Root-Aphis and the Control of its Injuries; in Ill. Agri. Exp. Sta. Bull., 178, pp. 405—466.

12. Hyslop, J. A. — 1915. Wireworms attacking Cereal and Forage Crops; in U. S. Dept. Agri., Bull., 156, pp. 1—34.
13. Komp, W. H. W. — 1920. The Use of Carbon Bisulphide against the White Grub; in Soil Science; 10, pp. 15—28.
14. Marie, P. — 1926. Utilisation de la Naphthaline pour éloigner les hannetons femelles au moment de la ponte; Observations diverses; in Rév. Path. Vég. et Ent. Agric., 13, pp. 39—48.
15. Marion, A. F. — 1877. Traitement des Vignes Phylloxérées par le Sulfure de Carbine; P. Dupont, Paris.
16. McColloch, J. W., and Hayes, W. P. — 1922. The Reciprocal Relation of Soil and Insects; in Ecology, 3, pp. 288—301.
17. Morris, H. E., and Swingle, D. B. — 1922. Injury to Growing Crops caused by the Application of Arsenical Compounds to the Soil; in Journ. Agr. Res., 34, pp. 59—78.
18. Nougaret, R. L. and Lapham, M. H. — 1928. A Study of Phylloxera Infestation in California as related to Types of Soils; in U. S. Dept. Agri., Tech. Bull. 20, pp. 1—38.
19. Parker, J. R. — 1915. Influence of Soil-Moisture upon the Rate of Increase in Sugar-beet Root-louse Colonies; in Journ. Agri. Res., 4, pp. 241-250.
20. Strickland, E. H. — 1927. Wireworms of Alberta; in Uni. Alberta, Coll. Agri., Res. Bull. 2, 3—18.
21. Thomas, W. A. — 1911. Corn and Cotton Wireworms; in S. C. Agri. Exp. Sta. Bull., 155, pp. 3—10.

Discussion.

W. E. Hinds: — An additional method of control applying to certain soil-infesting insects, particularly white grubs, which has not been mentioned in the paper, is the biological control which may be exerted by a number of parasitic and predatory enemies. For example, it is reported that the importation of *Scolia manilae* from the Phillipines into Hawaii resulted in a remarkably high degree of control of the Chinese rose beetle, *Anomala orientalis.* Similarly, certain species of *Typhia* are credited with holding in check the infestation by *Ligyrus* or *Euetheola rugiceps,* which is an important pest in cane fields in Porto Rico. These are but two of many instances of effective biological control which might be mentioned.

Mr. Hayes replied that the species of *Typhia* are not all effective against white grubs in Kansas.

O. H. Swezey: — Relative to biological control of root grubs, it might be appropriate to mention here that in Hawaii *Anomala orientalis* has been completely controlled by the introduction of a digger wasp, *Scolia manilae*, from the Philippines. Grubs of *Anomala* were found injuring cane roots in a small area in 1912. For a few years the pest spread at the rate of half a mile per year, and threatened to occupy the whole cane area of Oahu. In 1916, *Scolia manilae* became established, and within two years had checked the spread of *Anomala* and reduced it so that it was no more injurious. A rare insect now.

Arthur Gibson: — I was very much interested in the paper which has been presented by Doctor Hayes. Regarding the natural control of such soil-infesting insects as white grubs, it may be of interest to state that in Quebec Province these grubs are some years parasitized to an important extent by the Tachinid *Microphthalma michiganensis.* On two occasions we forwarded to the New Zealand Government consignments of parasitized grubs in the hope that they would attack species of Chafers of the genus *Odontria.*

The Present Status of our Knowledge of the Nyssorhynchus group of Anopheline Mosquitoes.

Francis Metcalf Root, Ph. D.,
School of Hygiene and Public Health, The Johns Hopkins University, Baltimore.

The *Nyssorhynchus* group of Anopheline mosquitoes, which includes such well-known species as *A. albimanus, A. tarsimaculatus, A. argyritarsis,* etc., is confined to tropical America, ranging from the southern borders of the United States to the northern part of Argentina. Throughout most of this area, roughly from Mexico to Brazil, species of this group are the most abundant and domestic Anophelines and the most dangerous vectors of malaria.

In addition to the great sanitary importance of this group of mosquitoes, they are also extremely interesting to an entomologist, because they appear to be a recently evolved group in which there exist a considerable number of very closely related forms. The present status of our knowledge (or perhaps I should rather say, our ignorance) of this group of mosquitoes may be briefly summarized as follows.

Taxonomy and Distribution. — Only a few years ago it was generally believed that the *Nyssorhynchus* group included only two or three species. For a time all the forms with wholly white tips to the hind legs were lumped together as *A. argyritarsis,* and those with a black ring on the last hind tarsal joint were all called *A. albimanus,* even *A. tarsimaculatus* being rated as a variety of *albimanus.* Even as recently as 1924, when Col. Christophers published his catalogue of the *Anophelini,* he tentatively recognized only three species, *argyritarsis, albimanus* and *tarsimaculatus,* all other names being listed as synonyms or varieties of these three. The Argentine and Brazilian entomologists were the first to realize that there were a number of related forms confused under these names, but their efforts to define and name the species were not altogether convincing, partly because they were not familiar with the Central American fauna, but especially because they relied primarily on the adult color-pattern and scalation for differential characters.

During a trip to Brazil in 1925, undertaken at the request of the Rockefeller Foundation, I was lucky enough to discover that the forms present in that country, while confusingly similar to each other in their adult markings, could be readily separated by the use of characters found in the larvae and the male hypopygia. More recently I have had an opportunity to study the species of this group which occur in Venezuela, and a great deal of valuable information on the faunas of Argentina and Chile has been obtained by R. C. Shannon and Dr. N. C. Davis.

In particular, Davis (1928) has shown that the extent of the black area on the second hind tarsal joint (which I find to be a very useful character for making field identifications in this group) not only differs in different species, and in the same species in different geographic regions, as I had already pointed out, but also differs in the same species in the same locality at different seasons of the year. That is, not only do certain species show more black in this position than do others, but nearly all species show more black in winter than in summer. Taken in connection with my previous observation that, in each species, the extent of the black on the second hind tarsal increases as one recedes from the equator in either direction, this seems to indicate that we are probably dealing with a direct effect of the temperature. This means that, while this character is most useful in making field identifications, it must be used with great caution until the composition of the fauna of the region studied has been worked out in detail by the use of hypopygial and larval characters.

At any rate, we are now reasonably certain that there are at least four species of the *argyritarsis* type, with the last three hind tarsals entirely white; four or possibly more species of the *albimanus-tarsimaculatus* type, with a black ring on the last hind tarsal; and three species or varieties of the *rondoni* type, with two or more black rings in the white area at the tips of the hind legs.

In the first series, *argyritarsis* itself ranges from Mexico to Brazil without essential modification. In Argentina, however, the male hypopygium shows slight differences from the normal type, and Bréthes (1926) has given this form the name of *Cellia rooti*. This may possibly deserve to rank as a geographical variety or subspecies. I have recently received a large series of specimens from Paraguay which appear, on superficial study, to include a mixture of typical *argyritarsis* and of *rooti*. When this material has been carefully studied, we may have a better idea of the correct position of Bréthes's name. *A. allopha* Peryassú (1921), described from Brazil, is a synonym of *argyritarsis*. Peryassú was quite right in distinguishing two species in his "*argyritarsis*" material, but he overlooked the fact that both had already been named, the common species being *albitarsis* Lynch Arribalzaga, while the rarer one, which he took to be new, was really the true *argyritarsis*.

A. albitarsis is a very interesting species. In Brazil, the typical form is common in the coastal lowlands in the vicinity of Rio de Janeiro, and this same form is found in northern Argentina and in Paraguay. In the interior of Brazil, separated from the coastal form by mountain ranges and a high plateau, occurs the form which Chagas described as *Cellia brasiliensis* and which I (Root, 1926) have treated as a variety of *albitarsis*. This form is identical with typical *albitarsis* in larval and hypopygial characters, but differs quite decidedly in size and in adult coloration, the latter bearing a rather close resemblance to that of *argyritarsis*. Last summer I found still another form, intermediate in adult coloration between typical *albitarsis* and *brasiliensis*, present in large numbers in the great plains or "llanos" north of the Orinoco River in Venezuela. These three forms of *albitarsis* probably represent only three points in a continuous area of distribution, and are hardly worthy of

varietal rank. Probably study of intermediate faunas would bring to light connecting forms.

The other two species of this first series may be dismissed more briefly. *A. darlingi* Root, which I found fairly commonly in the coastal lowlands of Brazil, also occurred rarely in Venezuela, but has not been found in Argentina or Paraguay. The adult appears superficially to be intermediate in coloration between *argyritarsis* and *albitarsis,* but the male hypopygium is distinct and the larva and pupa show certain striking peculiarities which cannot be matched by any other described species of *Anopheles,* New World or Old. The last species, *A. pictipennis* Philippi, was originally described from Chile in 1865, but has only recently been rediscovered in the same country by Edwards and Shannon. Unfortunately, they did not secure the male, but the adult coloration of the female is distinct from all the related forms, and Edwards's brief account of the larva (Dyar, 1928, p. 441) would seem to indicate that it also is abundantly distinct, combining some characteristics of the larvae of *albimanus* and *argyritarsis.*

In the second series, *A. albimanus* ranges from Florida and Texas to Venezuela and Ecuador, while *A. tarsimaculatus* is found from Nicaragua and Panama to Brazil and Argentina. The females of these species can usually be distinguished by the coloration of the palpi, but occasional specimens are difficult to place. The hypopygia and larvae are entirely distinctive, however. *Cellia oswaldoi* Peryassú and *Cellia evansi* Bréthes appear to be synonyms of *tarsimaculatus.*

A. strodei Root was originally found replacing *tarsimaculatus* in the interior of Brazil, and specimens have also been found in Paraguay, Venezuela and Panama. The adult coloration presents no distinctive differences from *tarsimaculatus,* but the larval and hypopygial characters show decided differences.

A. bachmanni Petrocchi was originally described from the north-eastern corner of Argentina. I have also received specimens from near-by regions in Paraguay. Shannon and his co-workers have described two other very closely related species or varieties from north-western Argentina. One of these, *A. perezi,* is known only in the female and is of somewhat darker coloration than typical *bachmanni.* The other, *A. davisi,* is somewhat lighter in color than *bachmanni* and shows slight, but apparently constant, differences in larval and hypopygial characters. In Venezuela I found a form which seems indistinguishable from *davisi* to be widely distributed and common in suitable breeding-places. This apparently discontinuous distribution shows how much we have still to learn about the species of this group.

Perhaps the most puzzling, and certainly the least-known series of these mosquitoes is that which includes *A. rondoni, A. cuyabensis* and *A. triannulatus.* These three species were described by Neiva and Pinto (1922, 1923) from females captured in the state of Matto Grosso, Brazil, near the Bolivian frontier. They differ from the members of the other two series in having black rings, not only on the fifth hind tarsal, but also on either the third hind tarsal *(rondoni),* the fourth hind tarsal *(cuyabensis),* or both *(triannulatus).* I suggested (Root, 1926) that these three forms might all be varieties of one species, but this seems less probable at the

present time, for Shannon and Davis have met with *A. rondoni* in some numbers in Argentina, and Davis has reared a number of families of adults from the egg, proving that this form breeds perfectly true. They have also secured the male and the larva of *rondoni* and find that its larva and male hypopygium are practically indistinguishable from those of *strodei.* This is very surprising, and leaves me in doubt as to the validity of my previous assumption that any two forms with identical larvae and male hypopygia should be treated as varieties of a single species. In adult coloration, *rondoni* is entirely distinct from any species of the other two series, differing not only in the color-pattern of the hind leg, but also in that of the wing. And Davis has shown that these characteristics breed true. Yet study of specimens of the larva and male hypopygium, kindly presented to me by Dr. Davis, has so far failed to reveal any definite differences from the corresponding structures of *strodei.* It will be most interesting to see what characteristics are presented by the larvae and male hypopygia of *cuyabensis* and *triannulatus,* when someone is fortunate enough to secure them.

Malaria transmission. — Our knowledge of the relations of these different forms to the transmission of malaria is nearly as unsatisfactory as is our knowledge of their taxonomy. The best evidence on this point comes, of course, from dissections to determine the indices of infection of the various species. The only data of this sort yet published are the series of experimental infections carried out by the late Dr. S. T. Darling (1910) in Panama, and the series of dissections of wild-caught females made by Dr. Mark F. Boyd (1926) in Brazil. Darling, in Panama, proved that *albimanus* and *tarsimaculatus* were both readily infected by the malaria parasites, while *argyritarsis* did not become infected in the experiments which he tried with that species. In Brazil, Dr. Boyd proved that one of the species of the *argyritarsis* series (probably *albitarsis)* was the principal vector of malaria, while *tarsimaculatus* was also infected in nature, but to a lesser extent.

It is also possible to draw tentative conclusions as to the rôle played by the different species of *Anopheles* in the transmission of malaria by comparing their distribution with that of the disease. Such conclusions agree, in general, with the results of dissection in indicating that *albimanus* and *albitarsis* are probably the most dangerous malaria-carriers of the group, while *tarsimaculatus* is less dangerous, but still a carrier of sanitary importance.

In the Caribbean region, malaria is usually associated with the presence of *A. albimanus,* except in the Lesser Antilles, where *tarsimaculatus* may be the vector. A definite proof of the abilities of *albimanus* as a vector is afforded by recent events in Barbados. This island has always been remarkable on account of the entire absence from it of both Anopheline mosquitoes and endemic malaria, but within the last year an accidental introduction of *albimanus* has been followed by a malaria epidemic.

In most other regions of South America, it seems very probable that *A. albitarsis* and its varieties are the main vectors of malaria. The typical form of this species was the most abundant and domestic Anopheline during the malaria season in the Brazilian area so intensively studied by

Dr. Boyd, and in the interior the *brasiliensis* form seemed to be similarly associated with severe malaria. In Venezuela also, a form of *albitarsis* was the most abundant Anopheline in the upper "llanos", which have the reputation of being the most malarious region of the country.

A. tarsimaculatus has also been shown to be capable of carrying malaria, and it may play a part in the transmission of the disease, particularly in the Lesser Antilles, where neither *albimanus* nor *albitarsis* have yet been reported. Of the other species which are at all common, *argyritarsis* and *strodei* are probably not important carriers, since they appear to be most abundant in highland regions where malaria is rare or absent. *A. darlingi* and *A. bachmanni* and its relatives, on the other hand, might possibly be of importance, although no evidence in either direction is available as yet.

Synonymy of the species of the *Nyssorhynchus* group.

1. First series.

Anopheles (Nyssorhynchus) argyritarsis Robineau-Desvoidy 1827.
Synonym — *Cellia allopha* Peryassú 1921.
Possible varieties — *argyritarsis* (Mexico to Brazil and Paraguay).
rooti Bréthes 1926 (Paraguay and Argentina).

Anopheles (Nyssorhynchus) darlingi Root 1926 (Brazil and Venezuela).

Anopheles (Nyssorhynchus) albitarsis Lynch Arribalzaga 1878.
Possible varieties — *albitarsis* (Argentina, Paraguay, Brazil).
brasiliensis Chagas 1907 (interior of Brazil).
Venezuelan form ("llanos" of Venezuela).

Anopheles (Nyssorhynchus) pictipennis Philippi 1865.
Synonym — *Cellia bigotii* Theobald 1910 (Chile).

2. Second series.

Anopheles (Nyssorhynchus) albimanus Wiedemann 1821 (Florida and Texas to Venezuela and Ecuador).
Synonyms — *Anopheles cubensis* Agramonte 1900.
Anopheles argyrotarsis albipes Theobald 1901.
Anopheles dubius Blanchard 1905.

Anopheles (Nyssorhynchus) tarsimaculatus Goeldi 1906 (Nicaragua to Brazil and Argentina).
Synonyms — *Anopheles gorgasi* Dyar and Knab 1907.
Cellia oswaldoi Peryassú 1922.
Cellia evansi Bréthes 1926.

Anopheles (Nyssorhynchus) strodei Root 1926 (Panama, Venezuela, Brazil, Paraguay).

Anopheles (Nyssorhynchus) bachmanni Petrocchi 1925.
Possible varieties — *bachmanni* (N. E. Argentina, Paraguay).
davisi Paterson and Shannon 1927 (N. W. Argentina, Venezuela).
perezi Shannon and Del Ponte 1928 (N. W. Argentina).

3. Third series.

Anopheles (Nyssorhynchus) rondoni Neiva and Pinto 1922 (Matto Grosso, Brazil; N. W. Argentina).

Anopheles (Nyssorhynchus) triannulatus Neiva and Pinto 1922 (Matto Grosso, Brazil).

Anopheles (Nyssorhynchus) cuyabensis Neiva and Pinto 1923 (Matto Grosso, Brazil).

Literature.

1. Mark F. Boyd. — 1926. Studies of the epidemiology of malaria in the coastal lowlands of Brazil; in Amer. Journ. Hyg. Monographic Series, No. 5.
2. Jean Bréthes. — 1926. Description provisoire de deux espèces nouvelles d'Anophelinae argentines; in La Prensa Medica Argentina, Año 13, Num. 3, pp. 106—107.
3. S. R. Christophers. — 1924. Provisional list and reference catalogue of the Anophelini; in Ind. Med. Res. Memoirs No. 3.
4. S. T. Darling. — 1910. Factors in the transmission and prevention of malaria in the Panama Canal Zone; in Ann. Trop. Med. and Parasit., 4, pp. 179—224.
5. N. C. Davis. — 1928. A consideration of variability in the Nyssorhynchus group of the genus Anopheles; in Amer. Journ. Hyg., 8, pp. 539—563.
6. H. G. Dyar. — 1928. The Mosquitoes of the Americas: Carnegie Institution of Washington, Publication No. 387.
7. A. Neiva e C. Pinto. — 1922. Contribuição para o conhecimento do Anophelinos do Estado do Matto Grosso com a descripção de uma nova especie, Cillia rondoni; in Brazil-Medico, Anno 36, Vol. 2, No. 46.
8. A. Neiva e C. Pinto. — 1922. Consideraçães sobre o genero "Cellia" Theobald, com a descripcão de uma nova especie; in Brazil-Medico, Anno 36, Vol. 2, No. 48, pp. 5—8.
9. A. Neiva e C. Pinto. 1923. Sobre uma nova anophelina braziliera, *Cellia cuyabensis* nov. sp.; ibid. Anno 37, Vol. 1, No. 17, pp. 5—7.
10. A. Peryassú. — 1921. Os Anophelinos do Brazil; in Arch. do Museo Nacional, Vol. 23.
11. F. M. Root. — 1926. Studies on Brazilian mosquitoes. I. The Anophelines of the Nyssorhynchus group; in Amer. Journ. Hyg., 6, pp. 684—717.

Some Effects of Temperature and Moisture upon the Activities of Grasshoppers and their Relation to Grasshopper Abundance and Control.

J. R. Parker,
Entomologist, Montana Agricultural Experiment Station, Bozeman, Montana.

I. INTRODUCTION.

In a paper read by the author before the American Association of Economic Entomologists at Kansas City in December, 1925, attention was called to the effect of temperature upon the amount of food consumed and the number of eggs laid by grasshoppers. In the present paper the effect of temperature and, to a lesser extent, moisture, upon other life processes and activities will be discussed. For the sake of brevity and general interest tabulated data and detailed description of methods will not be presented, but anyone desiring this information may obtain it by consulting the author.

II. INFLUENCE OF TEMPERATURE UPON EGG DEVELOPMENT.

At the risk of losing your interest right at the start, I am going to present some rather dry data on the rate of development of grasshopper eggs under various conditions of temperature. I am doing this because these data seem to answer a question which puzzled me for years and which has perhaps puzzled other entomologists. This question is: "Why do grasshopper eggs which are laid over a period of four or five months during the summer and fall hatch within a period of only a few days the following spring?"

1. Rate of Development when Eggs are placed at constant high temperature as soon as laid.

When eggs of The Lesser Migratory Grasshopper *(Melanoplus atlanis* Riley) were placed in moist sand the day they were laid and held at constant temperatures of 22, 27, 32 and 37° C, they hatched first at 27° C, the average time being 26 days. At 22° C, five degress lower, the average time to hatch was 147 days, while at 32° C, five degress higher, the average time was 32 days, and at 37° C, 46 days. Eggs held at 27° C hatched in the shortest time and with the least variation, all of the viable eggs hatching within a few days after hatching had once begun. At 22° C there was a wide variation, eggs in the same pod often hatching intermittently over a period of several months. At 32 and 37° C the variation in time of hatching was greater than at 27° C, but not as much as at

22^0 C. Of these four temperatures, 27^0 C therefore is the optimum, development being retarded at temperatures both above and below it.

2. Rate of Development when Eggs were placed at 0^0 C as soon as laid and later returned to constant high Temperatures.

When eggs were placed at 0^0 C (below developmental zero) immediately after they were laid, and later placed at constant temperatures of 27, 32 and 37^0 C, very different results were obtained, the eggs developing much more rapidly than when placed directly at these temperatures.

Acceleration in rate of development following exposure to low temperatures varied directly with the constant high temperature to which the eggs were returned. Thus at 27, 32 and 37^0 C the largest accelerations obtained were respectively 136.7%, 357.5% and 558%, while the average accelerations for these three temperatures were 66.3%, 136.9% and 212.2%. An exposure to 0^0 C for 500 days gave an average acceleration of 83% at 27^0 C, 200% at 32^0 C and 378% at 37^0 C. Acceleration in rate of development expressed on a percentage basis was computed as follows: If any stage in the life history were completed in 10 days, the growth rate would be 10% of total development per day. If the length of the stage was by some means reduced to 5 days, the growth rate would then be 20% of total development per day, or an acceleration in rate of development of 100%.

Acceleration at all three constant high temperatures increased quite uniformly as the length of the exposure to low temperatures was increased until a period of 240 days reached. Extending the period of exposure from 240 to approximately 500 days resulted in only slightly increased acceleration. The acceleration at all three temperatures following a 240 days exposure to low temperatures was as great as in some of the individual records for exposures of 500 days, and only slightly below the average of all records from 478 to 507 days. Extending the length of exposure from 478 to 507 days gave no definite increase in acceleration at any temperature, indicating that maximum acceleration had already been attained. It may therefore be concluded that the length of exposure at 0^0 C necessary to produce maximum acceleration is somewhere between 240 and 478 days, with the probability that an exposure of 300 days will come very close to producing maximum acceleration.

3. Rate of Development when partially developed Eggs are held at low Temperatures and later returned to constant high Temperatures.

Eggs which had previously been allowed to attain varying degrees of development at a constant temperature of 22^0 C before exposure to low temperatures, also exhibited marked acceleration when they were later placed at constant temperatures of 27, 32 and 37^0 C, the acceleration varying directly with the temperature to which they were returned. There was a marked difference, however, in the length of exposure at low temperature necessary to produce maximum acceleration, partially developed eggs receiving maximum acceleration after an exposure of 60 days

at low temperature, while undeveloped eggs, as stated in the previous paragraph, require approximately 300 days.

In this experiment one series of eggs was exposed to a low temperature of 8° C and another series to 0° C. It was found that eggs of the same stage of development previous to exposure and exposed for the same length of time, developed faster after being held at 0° C than at 8° C. As an example, the average acceleration at 32° C following exposure to 8° C was 254.5%, while after exposure to 0° C it was 377.4%. This is rather significant, since it presents a strong argument against the contention that might be raised, that the apparent increase in rate of development following exposure to low temperatures is not really an acceleration but instead may be caused by some egg development continuing at temperatures usually considered below the developmental zero. Of course, there is a possibility that the embryo may develop to a slight extent at 8° C, even though hatching would never take place at this temperature, but if acceleration is to be explained on this basis we would naturally expect more development to take place at 8° C than at 0° C, and a correspondingly less time necessary to hatch when returned to constant high temperatures. Instead, the reverse was found to be true, indicating that exposure to low temperature results in a real acceleration.

Bodine (1925) has noted that exposure of partially developed grasshopper eggs to low temperatures produce an accelerative effect on subsequent development at constant high temperatures. However, with the species used in his experiments no acceleration was obtained after undeveloped eggs had been exposed to low temperatures.

4. Discussion of the effect of Temperature upon Rate of Development.

From the data presented, it is clear that there is a marked difference in the rate of development of grasshopper eggs when placed at high temperatures immediately after they are laid, as contrasted with egg development after exposure to low temperatures either before or after some development has taken place. The rate of development after such exposures to low temperatures increased directly with all three temperatures used in the experiment — 27, 32 and 37° C —, while without exposure to low temperature, increases in temperature above 27° C caused a decrease in rate of development.

Retardation in egg development at high temperature is decidedly beneficial to *M. atlanis*. This grasshopper starts laying eggs in July and continues until cold weather comes in the fall. The earlier laid eggs are frequently exposed to soil temperatures above 37° C and if the rate of development increased at high temperatures many eggs would hatch during the late summer, after it was too late to complete nymphal development and deposit eggs. Such late-hatched grasshoppers would die in the fall without having reproduced. On the other hand, eggs laid during comparatively cool weather in the late summer and early fall develop faster than eggs laid earlier in the season and, as a result, all eggs go into the winter at much nearer the same stage of development than would be the case if the rate of development increased directly with temperature.

It has been shown that exposure of *M. atlanis* eggs to low temperatures results in a greatly increased rate of development when they are returned to higher temperatures. In nature, partially developed eggs are exposed to low temperatures for long periods during the winter months, which would result in an acceleration in development the following spring similar to that obtained in laboratory experiments. That such is the case is evidenced by the fact that all eggs under the same general soil moisture and temperature conditions do hatch within a very few days after general hatching has once started in the spring. Were it not for this acceleration, eggs laid late in the fall would hatch weeks or even months later than earlier laid eggs which had completed most of their development before exposure to winter conditions.

In the retardation of development at high temperatures during the summer, more rapid development during cool weather in the fall and accelerated development in the spring, due to exposure to low temperature during the winter, there exists a set of factors which tends to bring about complete hatching during a few days in the spring of all eggs laid over a period of several months during the previous summer and fall. This is a distinct advantage to the species, for it confines the nymphal period to the spring season when green succulent food is always available, at least during the early instars. It also brings practically all individuals to maturity at the beginning of the summer and thus allows a maximum time for egg-laying.

While complete egg hatching during a short period is an advantage to the species under natural conditions, it is also an aid to man in grasshopper control. If hatching should continue over as long a period as that during which the eggs were laid the previous year, grasshopper campaigns would extend from spring until late fall, whereas it is now possible in a well-conducted campaign to finish by July 1.

5. Comparison of Constant and Alternating Temperatures.

In order to compare the effects of constant and alternating temperatures, eggs of *M. atlanis* were collected in the field in April and lots of 200 each were held at constant temperatures of 27, 32 and 37° C, while a similar series was kept for 16 hours daily at 12° C (below developmental zero) and at 27, 32 and 37° C for 8 hours daily. At 27° C constant temperature, eggs hatched in 7 days. At an alternating temperature of 12 and 27° C the actual time to hatch was 14 days, but only a third of the total time was spent at 27° C, two-thirds of the time being spent at 12° C, which is below developmental zero. This gives a comparison of 7 days at a constant temperature with 4.6 days at the alternating temperature, or an increase of 51% in rate of development due to alternating temperature. At 32° C constant temperature the time necessary to hatch was 5 days, while at an alternating temperature of 12 and 32° C hatching occurred after 3 actual days at 32° C, an increase of 66% in rate of development. At a constant temperature of 37° C the time necessary to hatch was 4 days, while at an alternating temperature of 12 and 37° C hatching occurred after 2.6 actual days at 37° C, an increase of 52% in rate of development.

In a similar experiment eggs were held at 27, 32 and 37° C for 8 hours and for 16 hours daily at 22° C, which is above developmental zero. In every instance the actual amount of development per day for any two alternating temperatures was greater than when computed on the basis of constant temperature rates. This means that rates of development as determined in constant temperature cabinets cannot be used directly in forecasting when eggs will hatch in Nature where temperatures alternate between high day temperatures and lower night temperatures. Pears (1928) and Shelford (1926) in recent papers have also called attention to differences in rate of development at constant and alternating temperatures.

6. Air and Soil Temperatures at which Grasshopper Eggs hatch.

In preparing for grasshopper control campaigns it is important to know what temperatures bring about general hatching of eggs during the spring months. Observations based on the first appearance of nymphs in abundance in the spring, reports from county agents and a study of weather records show that in Montana general hatching of our two most abundant grasshoppers, *M. atlantis* and the Warrior Grasshopper *Camnula pellucida* Scud., takes place during the first warm period of from 3 to 5 days having maximum air temperatures above 24° C (75.2° F). Such warm periods generally do not occur in Montana until the last two weeks in May or the first week in June, and over a long period of years general hatching has rarely occurred before May 15.

An exception to this occurred at Havre, Montana, in 1926, and affords an excellent illustration of the effect of temperature upon grasshopper abundance. During the summer of 1925, grasshoppers were abundant enough to do considerable damage and by fall eggs were found in such enormous numbers that plans were made for an extensive control campaign the following spring. On April 14 the weather turned unseasonably warm, the maximum for the day being 26.6° C (80° F), and for six days the maximum was only once below 23.3° C (74° F). As a result a high percentage of the eggs hatched and the young nymphs gradually died during the cool, unfavorable weather that followed. When this area was visited early in May over 90% of the egg pods in bare soil had hatched, but in soil covered with weeds or straw eggs were still unhatched. Soil temperatures indicated the reason for the difference. With an air temperature of 22.2° C (72° F) at 4 feet, the temperature in bare dry soil at a depth of 2 inches was 25.5° C (78° F); under weeds in dry soil at the same depth 18.8° C (66° F); and in wet soil under weeds 16.6° C (62 F). Fortunately for the farmers of the region, only a small percentage of the eggs were thus protected and as a result of the early hatching of the greater part of the eggs in April, no control campaign was necessary, crops were not damaged, and the grasshopper population, which had given every indication of reaching outbreak proportions, was reduced to normal.

Many observations have been made in the field to determine the exact soil and air temperatures at the time hatching is taking place. Soil temperature at the point where the eggs are located is more important

than air temperature, for there is not always a uniform correlation between them. Moisture, color, texture, slope, and ground covering all directly affect soil temperature. As a result, hatching is uneven in the same locality, eggs in dry, black soil on bare south slopes hatching first, while eggs in wet or shaded soil may not hatch for weeks or even months later. In general, however, only a small percentage of the total number of eggs is in soil which for various reasons remains below normal in temperature, and in any one locality a very high percentage of the eggs hatch during the first period of warm weather in the spring, when maximum daily air temperatures are 24° C (75.2° F) or above, soil surface temperatures 27° C (80.6° F) or above, and soil temperatures at 2 inches 23° C (73.4° F) or above.

III. EFFECT OF MOISTURE UPON GRASSHOPPER EGGS.

Moisture has a direct influence upon the time of hatching of grasshopper eggs. Overwintered, field-collected eggs of *C. pellucida*, when held at a constant temperature of 27° C and at constant relative humidity ranging from 10 to 100%, failed to hatch at 10 and 20% R. H. At 30% they started to hatch in 13 days; at 50% in 12 days; at 60% in 11 days; and at 70, 80, 90 and 100% in 10 days.

Moisture as well as temperature also affects the percentage of eggs hatched. When overwintered, field-collected eggs of *M. atlanis* were held at constant temperatures of 22, 27, 32 and 37° C and at constant relative humidities ranging from 10 to 100%, 80% R. H. was found to be the optimum at 22° C, and 90% R. H. at 27, 32 and 37° C. The higher the temperature the narrower was the range of relative humidity at which hatching took place. Thus at 37° C no hatching took place except from 70 to 100% R. H., while at 22° C hatching occurred throughout the range from 30 to 100% R. H. An examination of the data shows a rather definite zone of temperature and relative humidity where conditions for hatching are at the optimum, and somewhat resemble in this respect P i e r c e's graph showing the relation of temperature and humidity to cotton boll-weevil activity (P i e r c e 1916).

When grasshopper eggs are placed at high temperatures and low humidities they lose weight rapidly and soon become shriveled. In one experiment 100 *M. atlanis* eggs and 100 *C. pellucida* eggs were taken from moist sand and placed at a constant temperature of 27° C and a relative humidity of 20—25 %. At the end of 4 days the *C. pellucida* eggs had lost 29% of their original weight and the *M. atlanis* eggs 51%. All appeared more or less shrunken. They were then returned to moist sand and in 10 days 97 of the *C. pellucida* eggs and only 42 of the *M. atlanis* eggs had regained their normal plumpness and closely approximated their original weight. Later 82% of the plump *C. pellucida* eggs and 80% of the plump *M. atlanis* eggs hatched and produced normal nymphs.

From the above it can be understood how disking or otherwise working the soil destroys at least a part of the eggs which it may contain. Such cultivation results in bringing to the surface and in breaking open some of the egg pods and exposes the individual eggs to higher temperature and lower humidities than eggs in undisturbed ground. As a

result many of the eggs shrivel and lose weight beyond the point where moisture coming at a later date can restore them to normal condition. The greater resistance of *C. pellucida* eggs to desiccation can be explained by the fact that its eggs have a heavier and tougher chorion than do those of *M. atlanis*.

IV. EFFECT OF TEMPERATURE UPON NYMPHAL DEVELOPMENT.

Comparison of constant and Alternating Temperatures.

The rate of nymphal development of *M. atlanis* increased directly with temperature at the four constant temperatures used. The average length of the nymphal period was 79 days at 22° C, 42 days at 27° C, 27 days at 32° C and 23 days at 37° C. These are the averages of hundreds of rearing records from several different sources.

When alternating temperatures were used, an acceleration in rate of development was found to take place similar to that described under the "Effect of Temperature Upon Eggs". In this experiment newly hatched nymphs of *M. atlanis* were divided into lots of ten each and held at constant temperatures of 27, 32 and 37° C, while a similar series was kept for 16 hours daily at 12° C (below developmental zero) and at 27, 32 and 37° C for 8 hours daily. At 27° C constant temperature the adult stage was reached in 54 days. At an alternating temperature of 12 and 27° C the actual time required to reach the adult stage was 105 days, but only a third of the total time was spent at 27° C, two-thirds of the time being spent at 12° C, which is below developmental zero. This gives a comparison of 54 days at a constant temperature with 35 days at alternating temperatures. At 32° C constant temperature the time required to reach the adult stage was 27 days, while at an alternating temperature of 32 and 12° C the adult stage was reached after 21 actual days at 32° C, an increase in rate of development of 28%. At 37° C constant temperature the adult stage was reached in 24 days, while at an alternating temperature of 37 and 12° C the adult stage was reached in 17 actual days at 37° C, an increase in rate of development of 41%.

These accelerations in rate of development for nymphal growth are quite similar in amount to the accelerations that took place in egg development at the same sets of temperatures.

In an earlier paper I called attention to the fact that although the length of the nymphal stage varied from 94 days at 22° C to 25 days at 37° C, the amount of food consumed was approximately the same at the four constant temperatures of 22, 27, 32 and 37° C. In the experiment with constant and alternating temperatures just reported, the amount of food consumed was also determined; and it is interesting to note that while the amount of food consumed during the nymphal stage at the three constant temperatures of 27, 32 and 37° C was approximately the same, there was a uniform reduction in the amount of food consumed at alternating temperatures. For the constant temperature the dry weight of the food consumed by ten nymphs was 6796 mg. at 27° C, 6959 mg. at 32° C and 7179 mg. at 37° C. At alternating temperatures

the dry weight of food consumed by ten nymphs was 4700 mg. at 27 and 12° C, 5061 mg. at 32 and 12° C and 4639 mg. at 37 and 12° C. This amounts to a 24% reduction in the amount of food used during the nymphal stage. The average reduction in the length of the nymphal stage at alternating temperatures was 30%.

From the above it would seem that daily alternating temperatures are more favorable for growth, grasshoppers completing their nymphal stage in less time and on less food than at constant temperatures.

V. EFEFCT OF TEMPERATURE UPON THE NUMBER OF INSTARS AND UPON COLOR.

At constant temperatures of 22 and 27° C *M. atlanis* molts 6 times and therefore has 6 nymphal instars. At constant temperatures of 32 and 37° C there are only 5 nymphal instars. *C. pellucida,* which belongs to a different subfamily, passes through 5 instars at all four temperatures.

M. atlanis nymphs grown at 40° C produce adults which are a pale yellow or light orange in general color with the black markings much reduced. At lower temperatures the color becomes progressively darker, the few adults obtained at 22° C being almost black. In *C. pellucida* color changes are less pronounced, but the general tendency is toward dark-colored specimens at low temperatures and light-colored ones at high temperatures.

VI. EFFECT OF TEMPERATURE ON THE LENGTH OF TIME NECESSARY TO KILL GRASSHOPPERS BY IMMERSIONS IN WATER.

Temperature was found to have a marked effect on the length of time required to kill second instar nymphs of *C. pellucida* by inmersions in water.

A number of open vials, each containing 10 nymphs, were immersed in water which had previously reached a constant temperature. One vial from each temperature was removed every hour until a point was reached at which none of the ten nymphs recovered after being removed from the water and placed on filter paper. The time required to kill all ten nymphs was as follows: 3 hours at 37° C, 7 hours at 32° C, 13 hours at 27° C, 19 hours at 22° C, 20 hours at 19° C, 36 hours at 17° C, 60 hours at 12° C, 72 hours at 7° C and 84 hours at 0—1° C.

This indicates that flooding grasshopper-infested fields with irrigation water during very warm weather would be much more effective in killing grasshoppers than during cold weather. It also explains why heavy rains of short duration during cool weather in the spring fail materially to decrease the grasshopper population.

VII. TEMPERATURE LIMITS OF *M. ATLANIS.*

The economic entomologist is concerned with many of the direct effects of temperature upon grasshoppers. He is often asked if eggs or young grasshoppers have been killed after a spell of unusually cold weather in the winter or spring, and what high temperatures are necessary to kill the eggs, nymphs, and adults. A knowledge of the temperature

limits of activities such as feeding, egg-laying, migration of young grasshoppers, and flights of adults is also of considerable importance in conducting effective control campaigns. I have, therefore, constructed what might be called a grasshopper thermometer on which are indicated some of the more important temperature limits of *M. atlanis.* The temperatures given are based on 40 continuous days' observation in the field in Montana during the summer of 1924, supplemented by miscellaneous field observations and laboratory experiments extending over a period of 10 years.

Beginning at the lower end of the scale, it was found that a 16-hour exposure at a constant temperature of —30° C (—22° F) killed 100% of the eggs, while at —25° C (—13° F) approximately 50% of the eggs were viable after an exposure of the same length. The average freezing point of uninjured eggs as determined by the thermocouple method described by Carter (1926) was —19.5° C (—3° F), and the average undercooling point was —21° C (—5.8° F). Freezing did not kill the eggs, however, for many of them hatched after they had been carried several degress below their freezing and undercooling points, and as was just pointed out, 50% of the eggs survived a 16-hour exposure to a temperature of —25° C (—13° F). When the egg shell was pierced by the thermocouple point, or otherwise injured, the egg contents undercooled to —4.5° C (23.9° F) and froze at —2.5° C (27.5° F). These same temperatures were also found to be the undercooling and freezing points of nymphs which had just hatched.

Second and third instar nymphs survived a 24-hour exposure at a constant temperature of —7° C (19.4° F), but were all killed by a 48-hour exposure at —8° C (17.6° F), a 24-hour exposure killing only about 5%.

Adults packed in snow and placed at 0° C (32° F) lived for 17 days.

Adults and nymphs held at constant temperatures of 8 and 12° C (46.4 and 53.6° F) did not feed and lived for the same time at both temperatures, the adults living 22 days and the nymphs 17 days. Both nymphs and adults fed slightly at 16° C and died sooner, the adults living 12 days and the nymphs 11 days. This point was checked several times and it was found that in the narrow zone where temperature is barely high enough to bring about slight feeding and activity, death always occurs sooner than at low temperatures at which there is no feeding, and at higher temperature where normal activities are taking place. This suggests a possible explanation of the high death rate among young grasshoppers when unseasonably warm weather causes the eggs to hatch early in the spring. Very cool weather usually follows during which the young hoppers are kept on the border-line of inactivity for days at a time.

Developmental zero for eggs and nymphs is very close to 17° C (66.6° F). Nymphs will not feed nor molt and eggs that hatched in 2 days at room temperature were held for 6 months without hatching.

Activity among nymphs and adults under natural conditions usually begins when an air temperature of 17° C (62.6° F) is reached. This is only an approximation, however, because it is the combined effect of air and soil surface temperatures that really arouses grasshoppers to activity. No activity has ever been noticed in the morning at soil temperatures lower than 20° C (69.8° F). When the air temperature reaches 20° C (69.8° F), grasshoppers are generally moving actively and beginning to

feed. Egg-laying and migrations of nymphal swarms have not been observed at air temperatures below 22° C (71.6° F) or soil surface temperatures of 32 and 33° C (89.6 to 91.4° F). Migrating bands of nymphs are very susceptible to temperature changes, movement ceasing abruptly if a passing cloud hides the sun and causes the air temperature to drop below 22° C, and starting promptly as soon as their air temperature again goes above that point.

When the soil surface temperature reaches 45° C (113.6° F), both nymphs and adults leave the ground and seek a more desirable temperature by climbing weeds and blades of grass. Since there is sometimes a difference of 40° F between the soil surface and the air 2 inches above the ground, a grasshopper is able to choose its own temperature by merely moving an inch or two up or down a blade of grass.

Flights of adults occur most commonly between temperatures of 27 and 30° C (80.6° to 86.0° F), but seem to be more dependent upon wind than temperature. A light breeze barely sufficient to ripple grass or standing grain, together with the temperature given above, will nearly always cause swarms to take to the air.

When nymphs and adults are confined in temperature cabinets they become excited and nervous whenever the temperature reaches 46° C (114.8° F). At 50° C (122.0° F) nymphs were still active after an exposure of 1 hour, but adults were in heat rigor. Both nymphs and adults were killed by a 2-hour exposure. At 53° C (127.4° F) both nymphs and adults were in heat rigor after a 5-minute exposure, but the nymphs recovered when removed from the cabinet. At 55° C (131.0° F) nymphs were killed by a 5-minute exposure.

Eggs survived 2-hour exposures at 45° C (113° F), but were killed by a 2-hour exposure at 50° C (122.0° F). At 60° C (140° F) eggs survived a 10-minute exposure and were killed by a 20-minute exposure.

VIII. RELATION OF TEMPERATURE TO THE EFFECTIVENESS OF POISONED BRAN MASH.

The use of poisoned bran mash has been the most effective method of killing grasshoppers in America. It is generally agreed that grasshoppers are most strongly attracted to poisoned bran mash when it is moist and giving off a distinct odor, a condition which exists for only a short time after it is scattered during dry weather. It is also commonly recognized that at times grasshoppers will not feed at all, no matter how attractive the bait, and that at other times periods of maximum feeding occur during which every grasshopper seems to be looking for food. Keeping in mind these two facts it may be definitely stated that poisoned bran mash will give best results if it is scattered so that its period of greatest attractiveness coincides with the period of maximum feeding of the grasshoppers it is supposed to kill. Failure to recognize this fact has, in the past, resulted in the absolute waste of many tons of poisoned bran mash scattered at times when grasshoppers refused to touch it.

Experiments conducted in Minnesota and in Montana have shown that temperature is a very important factor in determining the period of maximum feeding at poisoned bran mash. In Minnesota *C. pellucida* were observed in the field for 13 days. The results of this investigation were

published in *Minnesota Bulletin* No. 214 (Parker 1924). The Minnesota studies may be briefly summarized as follows: *C. pellucida* feeds sparingly at poisoned bran mash at air temperatures of 65 to 66° F (18.3 to 18.9° C), more actively at temperatures from 67 to 70° F (19.4 to 21° C), and most actively at temperatures from 71 to 77° F. The hour of maximum feeding generally occurred during that hour of the day which first had a mean temperature between 73 and 77° F (22.7 and 25° C). On days when the maximum hourly mean was below these figures, the hour of heaviest feeding occurred during the hour when the highest temperature for the day was first reached.

In Montana *M. atlanis* was observed in the field for 41 days, records being made at 10-minute intervals of the number of grasshoppers feeding, air and soil surface temperatures, and relative humidity. *M. atlantis* in Montana was found to have a slightly wider feeding range of temperature than *C. pellucida* in Minnesota. *M. atlanis* fed sparingly at poisoned bran mash at air temperature of 55 to 64° F (12.7 to 17.7° C) and at soil surface temperatures of 70 to 90° F (21 to 32.2° C); more actively at air temperatures of 65 to 69° F (18.3 to 20.5° C) and soil surface temperatures of 91 to 100° F (32.7 to 37.7° C), and most actively at air temperatures of 70 to 80° F (21.1 to 26.6° C) and soil surface temperatures of 100 to 113° F (37.7 to 45° C). Whenever the air temperature went above 80° F (26.7° C) or the soil surface temperature above 113° F (45° C), the number of grasshoppers feeding was rapidly reduced.

Most recommendations as to when poisoned bran mash should be put out have been based on time of day rather than on temperature. The data presented show that the period of maximum feeding by no means always occurs at the same hour of the day and that temperature is a better basis for making recommendations.

In general it may be said that poisoned bran mash should never be scattered for either *M. atlanis* or *C. pellucida* at air temperatures below 68° F (20° C) or above 80° F (26.6° C), and at soil surface temperatures below 90° F (32.2° C) or above 113° F (45° C), and that best results are to be expected when it is scattered so that it will be moist and odorous when the air temperature for the day first reaches 70° F (21.1° C).

Literature.

1. Bodine, Joseph Hall 1925. — The Effect of Temperature on Rate of Embryonic Development of Certain Orthoptera; in Journ. Exp. Zool. 42, pp. 91—109.
2. Carter, Walter 1925. — The Effect of Low Temperatures on *Bruchus obtectus* Say, an Insect affecting Seed; in Journ. Agr. Res. 31, pp. 165—182.
3. Parker, J. R. 1924. — Observations on the Clear Winged Grasshopper; in Minn. Agr. Exp. Station Bul. 214.
4. Pears, L. M. 1927. — Some Phases of the Relation of Temperature to the Development of Insects; in West Va. Agr. Exp. Sta. Bul. 208.
5. Pierce, W. Dwight 1916. — A New Interpretation of the Relationships of Temperature and Humidity to Insect Development; in Journ. Agr. Res. 5, pp. 1183—1191.
6. Shelford, V. R. 1926. — An Experimental Investigation of the Relation of the Codling Moth to Weather and Climate; in Ill. Nat. Hist. Survey Bul. 16.

Silvicultural Practice in the Control of Forest Insects.

E. N. Munns and Perkins Coville, U. S. A. Forest Service, Washington, D. C.

Silviculture is the art of producing and tending forests. It calls for the application of our knowledge of silvics and of forest ecology in the treatment of the forest. Silviculture in America is still in the making. Knowledge is obtained slowly and painstakingly. Experiment and experience working together are laying the foundation for those cultural practices which can be applied under our local conditions.

Many years are required to grow timber to marketable size. Investments in the forest during a rotation result is a heavy money charge against the final crop. This charge is costly enough even with the high yields obtainable with proper silvicultural management, but may become exorbitant with a reduction in the amount of timber produced. Not infrequently does the damage caused by fires, insects, disease, and even by forest wild life, turn the venture from a highly profitable one to one with only a narrow margin of profit, necessitating the radical modification of management plans. Because of this, measures of protection from and control of all sources of injury are among the most important conditions of forestry practice. Yet, until an emergency exists, these exceedingly important conditions are too often slighted and occasionally are all but neglected in the management of our forest lands.

In many localities the protection of growing forests from insect damage seems to present insurmountable difficulties, particularly over large areas. The crop cannot be plowed under or even totally burned as a farmer might treat an infested field crop; another crop cannot — or at least cannot easily — be substituted except over a long term of years; forest trees cannot be given individual treatment because the present cost of spraying or dusting individual trees with insecticides is greater than is justified. Yet in all the American forest regions, we find that insect damage of one sort or another is reducing our already depleted stand of timber, or reducing or inhibiting the new growth that we need for our future supply of wood.

There are of course a host of insects causing sufficient damage to forests and forest trees to be worthy of attention; the gall flies, the bark beetles and wood borers, the leaf feeders and miners, and the weevils, aphids and moths. With the many changes that are all the time taking place, such as a season favorable to the rapid development of an insect, a forest fire that injures, weakens or kills trees, or importation of some new tree species, some endemically unimportant insect becomes epidemic, and the forester finds himself confronted by a problem as serious as it may be

unexpected. When this happens, his best laid plans of management may do him little good; all his efforts to obtain desirable reproduction soon after logging, to favor and develop a stand of the best species, to thin his stand to obtain the maximum growth — all his efforts to obtain the highest possible yields are subject to radical modification in the light of the new conditions.

A few examples only from American forest practice will illustrate, how greatly insects may affect silviculture. Thus, the northern white pine *(Pinus strobus)*, producing a wood of great value, grows rapidly on many areas in the northeastern section of the United States. In some localities the white pine weevil *(Pissodes strobi)* attacks this valuable forest tree so severely that it can no longer be recommended as one of the best species for planting, and is almost eliminated from the silvicultural scheme. On this same section the pales weevil *(Hylobius pales)* is often abundant on cut-over areas. Ravenous feeders, they eat the bark from pine seedlings and prove a serious pest often practically destroying the reproduction, and plantations on freshly cut-over land are often wholly ruined.

Tamarack *(Larix laricina)*, a tree that grows more successfully than any other tree in the northern swamps, may become virtually extinct as a factor in forest production as a result of sawfly *(Nematus erichsoni)* damage, which now seems to be coming back to clean up the last larch reproduction. On large areas of swamps in the Lake States this tree was one of the few that would grow, and here larch has proven a valuable species. There seems to be no other species that can take its place.

The locust borer *(Cyllene robiniae)* has practically prevented the use of the black locust *(Robinia pseudoacacia)* in erosion control or in forest production. Attacks of bark beetles *(Dendroctonus* and *Ips)* in various yellow pines have caused radical modifications in logging. In northern California and southern Oregon silviculture is to no small extent modified by the predilection of some of these beetles *(D. monticolae* and *D. brevicomis)* for certain classes of western yellow pines *(P. ponderosa)*.

That silviculture, to reverse the tables, may be used with beneficial effect in the control of insects, has not been greatly considered here in America by foresters. That it can be so used, however, should be kept in mind by all foresters and entomologists, for it is through silviculture that we can, first of all, arrest the development of epidemics and, second, assist in actual control work. It remains to show how this may be accomplished.

Adaptive measures, such as eliminating susceptible species and replacing them with "resistant" ones is a slow process. Furthermore, we can never be sure when this has been accomplished, that our so-called "resistant" species will not be attacked by some old or new pest, perhaps by one that has heretofore confined itself to some other host, or by one that has been brought to us from another country where it is innocuous. The development of a new species, variety, or "strain" of a resistant pine appears well nigh hopeless when we read in one entomological publication that there are 22 leaf feeders, 61 borers, and 9 insects working in dead wood or under the bark, on pines in New York State alone. Bureau of Entomology records show that some 400 different species of insects work on the hickories.

Then, too, the Sonderegger pine, supposedly a hybrid of the longleaf and loblolly pines *(P. palustris* and *P. taeda)* of the southern Coastal Plain region, is reported to be more susceptible than either of its parents to tip-moth attack, both from those insects that attack the parents as well as from others. Although this one example does not prove that tree breeding may not be the means of producing resistant stock, it does furnish strong circumstantial evidence that we must know far more than we now do about the food and environmental requirements of the various insect species. If immune varieties can be developed, and some entomologists think that they can, a great step forward will have been taken; even the development of a highly resistant strain would be of value.

In this connection it is interesting to read *):

"The trees left (from the uncontrolled slashing of lumbermen) are not wholly those too small for the saw; they include trees of all sizes containing so great a percentage of defect as to be unprofitable to remove. And such trees are to be progenitors of the future forest! . . . The laws of heredity do not dictate that every progeny of a diseased tree shall be diseased; they do dictate that the occurrence of disease shall be common among such progeny, since a large proportion of the progeny will certainly be susceptible . . . . What has been said of tree diseases probably applies in principle to their insect enemies. The situation with regard to the planting of poorly adapted varieties and poor stock of forest trees in the United States appears . . . to threaten such huge losses of timber values in the aggregate as to warrant a practical step taken for its correction."

The pure forest is often — all too often — a source of grief to the practising forester and timberland owner. Attacked, the one-species or two-species stand is all too often hard hit by insects, and at times practically wiped out of existence. Thus various species of *Dendroctonus* have made quick work of some pines in parts of the United States; the spruce budworm during the height of epidemics has destroyed the forest on thousands of acres of the North-eastern United States and Eastern Canada, the hemlock looper has eliminated the hemlock from many acres; the larch sawfly has practically wiped out from many swamp areas the only tree species which can grow into a real tree there, and so on. What holds true here is true elsewhere — the pure forest, especially as it approaches maturity, is an unsafe forest.

If one species of the mixed forest is attacked and an epidemic threatens, the lack of an abundance of favorite food will often prevent the insect from becoming more than a threat. Certainly the chance of a widespread epidemic is greatly reduced. Even if a single species be taken from the mixed stand, the loss of that species is not disastrous to the owner, for other species keep the soil covered, keep the land productive, and keep the loss from becoming too serious. All in all the mixed forest is the safe forest, and so by proper silvicultural practices the threat of destruction from insect pests may be minimized. Thus by controlling mixtures through cuttings, through thinnings, through plantings, and

---

*) Bates, C. G. Better Seed Better Trees, in Journ. Forest 25, No. 2, p. 133.

through grazing, it is possible to build up the kind and type of forest which will in the long run be safest from destruction by insects.

It may be possible to control insect damage through the control of the forest density. Graham's investigations *) show that weevil infestation of young white pine stands varies with the density of the stand — from about 100% infestation with 400 trees to the acre to about 2% with 700 trees per acre. He also shows**) that if a density of 1200 to 1500 trees an acre is maintained throughout the early years of the rotation, and a fully stocked stand thereafter, the losses from weevil attack will be at a minimum. The junior author has noticed pine reproduction under older trees (shaded) very appreciably less affected than reproduction from the same older trees that established itself in an adjacent open field.

So, density of the stand may be a far more important factor in the control of insects than we have yet realized, and particularly so in the early life of the stand.

Site — or soil conditions — are also in a measure under the control of the forester. By maintenance of a cover, by growing a mixed forest, by properly tending the canopy, possibly by the use of fire, the forester can greatly modify the soil, gradually making the poorer soils richer through the addition of humus, and through the beneficial action of foraging roots, or soil sweeter, by removing the heavy mantle of raw humus. True, he cannot change the soil overnight in this fashion, and neither can he perform miracles, but a decided change can be brought about. Generally speaking, however, the better the site the less will be the insect damage, for it is usually the poor sites that suffer the most damage and that are most often ruined.

Craighead***) and others have indicated the close relationship between the growth rate and insect attack. The southern pine beetle *(D. frontalis)* is of importance chiefly during drouth years, when growth is slow. Person†) has shown that the slow-growing trees on cut-over areas in western yellow pine were hardest hit by *Dendroctonus.* Similar work by others is showing the same relationship, which, while not absolute, appears to hold rather closely within limits. If this is the case, does it not signify that silviculture can reduce insect losses by a good forest practice which will keep the stand growing thriftily and well? Does it not mean that foresters have in cuttings and thinnings measures which will reduce insect losses and assist in keeping dangerous insects from developing out of the endemic stage? We have not appreciated and do not yet appreciate to the full how effective this control may be.

Thinnings, too, can be used in the control of insect pests. Species which are subject to attack by insects when exposed fully to the sun, may be grown

*) Graham, S. A. Biology and Control, of the White Pine Weevil; Bulletin 49, Cornell Univ. Agric. Exp. Sta., 1926.

**) Graham, S. A. "The White Pine Weevil and Its Relation to Second-growth White pine", in Journ. Forest. XVI, 2, p. 192, 1918.

***) Craighead, F. C. Relation Between Mortality of Trees Attacked by Spruce Budworm and Previous Growth; in Journ. Agr. Res., March.15, 1925, p. 541.

†) Person, H. L. Tree Selection by the Western Pine Beetle; in Journ. Forest. 26; No. 5, 1928, p. 564.

in the shade of taller, immune trees. Trees of slow growth may be removed from the stand; trees of medium growth can be stimulated. Then, too, cuttings might be used to let in air, light, or warmth to the litter to prevent insect attack or to favor insect parasites, or thinnings may decrease the soil moisture with the same results. Furthermore, trees to come out of the stand in a thinning can be so treated — if desirable — as to create trap conditions and insects attracted to them may be destroyed in the removal of the tree. Where definite control measures might be too costly, thinnings or inprovement cuttings may be used.

The proper handling of slash and other débris created in logging may also control insects. Thus species which breed up in slash may be destroyed by burning this débris at the right time, and insects which normally attack standing trees may be encouraged to enter slash by creating a large amount of it during the period of flight. Other slash might be burned broadcast to destroy insects in the litter during the propagation period.

Fire may be used as a silvicultural agent. So far, however, the suggested use of fire in the forest meets with many objections, largely because of the fire danger and because of the lack of appreciation on the part of our careless public as to why fire should be so used and yet they be cautioned regarding the use of fire. Then, too, many foresters are so afraid of fire that they cannot see in its use an aid to proper management. But, rightly used and handled, and under conditions which the forester can learn to set up, there seems no reason why fire may not be used silviculturally to control composition of the stand, to eliminate competition, to reduce density, to create conditions favorable for reproduction. There appears no reason why fire could not also under certain specified conditions be used as a silvicultural agent in preventing the development of certain insects. Thus, if a stand is soon to be logged, fire might also be used to attract to the area insects which elsewhere are developing into a menace. We have not yet learned how to use fire as our ally, and it may well be that we shall find its use greatly circumscribed, but it may have a place and an important one in some of our types and stands in preventing and retarding the development of insect pests.

Thus there are a number of conditions in the forest that have been, or can be, influenced by silvicultural management, and that have an effect upon some insect attacks. Without generalizing too much, it is safe to say that there are many insects attacking forest trees that prefer pure stands to mixed stands, open stands to dense stands, or sunlight to shade, trees of one age class or height class to those younger or older, shorter or taller; weakened trees to healthy trees; a slash covered area to one upon which the slash has been burned; a site with much humus, leaf litter, or moisture to one that is barer or drier. There is hardly a factor entering into the development of the insect, or of the stand, that cannot be affected by silviculture, though to be sure more urgent needs, inaccessibility, or cost may prohibit silvicultural control at the present time. But we may find that the costs of some silvicultural control measures may be considerably less and much more satisfactory than the direct measures used so largely at present. And, it is not unreasonable to suppose

also that some of these control measures may more than pay their own way.

However, in America, for many reasons, including the lack of personnel (particularly a forestry minded personnel), funds, and sad to relate, of interest on the part of foresters and entomologists alike, there has been all too little investigative work directed toward the silvicultural end of forest entomology. In fact the recognition that forest entomology was but one phase of silviculture — albeit a very important one — is only about 5 years old. Progress has been made, but only to those who have been in intimate touch with developments is the full march of this progress really visible.

What I may have to say therefore is not in condemnation, but in real appreciation of the many difficulties which have confronted the work, to call attention to holes in our knowledge, and to point out wherein strength is needed.

Before we can hope to answer many of the perplexing questions facing proper silvicultural management of our stands, we should stand off at a distance and see wherein we have not made progress, and why — not as entomologists alone, but as foresters who have the silviculture and sanitation of a growing forest at heart. If we are to control insects through silviculture, research is necessary first of all upon many lines of effort. If forest entomology is to play its part in silvicultural management — and in the necessity for this we all agree, I am sure —, then there must be the closest cooperation between all agencies looking towards the proper tending of the forest. If we are to handle our forest lands properly, foresters must develop a keener appreciation of the problem and be thoroughly awake to it. If we are to use silviculture in the control of insects, we must depend upon foresters who are adequately trained not only in forestry but in forest entomology and in the silvicultural and ecological side of entomology as well.

For many years forest entomologists and foresters alike have operated on the theory that insect epidemics such as that of the bark beetles may be controlled through artificial measures even though these did not begin until the epidemics were well along. Of recent years, however, doubt has been expressed as to the effectiveness of artificial methods when applied to some of the bark beetles, because, whereas man has taken unto himself the credit for having controlled an epidemic, a similar attack elsewhere under similar conditions has suddenly of itself become endemic without the assistance of man.

Again, in other cases where every condition pointed to successful control, insect attacks have continued to be or have suddenly and unseasonably become serious, although scouting and theory indicated that the epidemic had been controlled. Man's efforts therefore have not always been the success that he has claimed; in some instances they have been futile. Is it not more than probable that natural forces have been responsible, natural forces the nature and extent of which we now but dimly suspect? Through research, these forces, if they exist, must be found; some method of indirect control that will serve as a prophylaxis or even replace the present costly methods is not only desirable, but is badly needed. In fact, it is essential for proper management.

In the last few years much effort in entomological research has been directed towards the ecology of insects and towards the causal factors responsible for epidemics. Thus, as already pointed out, the theory seems now well on its way towards proof that the growth rate was an indication of conditions favorable or unfavorable for successful attack by certain bark beetles. Theory, however, has not always checked with fact and, particularly in times of epidemics, the fast growing trees have been attacked and many of them killed. That there is a definite relationship between rate of growth and the successfulness of bark beetle attack is not to be denied, but just how far this relationship holds, why it should hold, whether it can be modified, yet remains to be worked out. There is no reason, however, to doubt but that further research will find there is more than an apparent relationship between growth rate or tree condition and insect attacks, not alone by bark beetles, but by other insects.

A slow growth rate may be due to a lack of soil moisture, for even where there appears to be plenty of moisture, competition in dense stands may so dry out the soil that conditions inimical to a high growth rate are created. Such aridity then makes it difficult for the weaker trees to obtain moisture. When a stand becomes stagnated over an exended period, is it unreasonable to believe that insect attack may be more successful than it otherwise would have been? Trees standing alone in the open do not have to put up with the competition of other trees, but they are in direct competition with the subordinate vegetation (grass, herbs, shrubs). Does this vegetation play the same rôle as a dense forest in removing water from the soil? Is the controlling factor the availability of water or is it the moisture content of the tree itself? To what extent is it desirable for us to conrol the growth rate? Is it not possible also that the moisture content of the cambium, or leaf, at some critical stage in the life history of the pest may be a controlling factor? If it is not moisture, may it not be food? Is there not the chance that by silvicultural practice we can so modify the soil that certain foods (or chemicals) may be stored or at least appear in the part fed upon? Is not the time approaching when we shall need the combined effort of physiologists, chemists, silviculturists, and entomologists on some such problem? Many of these things have been thought of, it is true, but funds have not been available, or personnel not at hand, or opportunities for work have not been forthcoming. Foresters, generally speaking, have been slower to recognize this than have the forest entomologists.

No research with which I am now familiar has been directed towards determining the kind, quality and amount of thinning that should be given young second growth pine stands to make them fairly free from insect attack. No serious research is apparently yet directed toward the effect of thrift upon bark beetle attack in second growth stands. No research has yet been directed upon the influence of grazing, upon the rate of growth and thriftiness of trees, and upon the susceptibility of the trees in heavily grazed areas to attack. Yet these are important silvicultural and entomological problems, and they are growing in importance each year.

Pathologists have given us the term "pathological rotation". This is the age at which stands should be cut in order to prevent loss due to

decay. Thus it has been found that decay begins to enter a stand of second growth in one species at 100 years, in another at 150, and the silviculturist must plan to cut before that age is reached if he is to cut sound timber. In the western yellow pine forests the old stands are overmature — in many places they average 250 or 300 years. In these stands, the bark beetles are working great havoc. Why did they not work earlier? Is 200 years the entomolgical rotation for this species, and if so, under what conditions of site and growth? True, we shall not raise trees in many areas to this age in our future stands, but should we not know the ages at which damage is most severe that it may not be exceeded? The tamarack in some localities has been practically wiped out in stands over 100 years or so old. Is 100 years the entomological age for tamarack and might we not raise tamarack in our swamps, if we kept within this age? Or what is the age limit? Will it apply to all species or on all sites? Is this not a phase of silviculture upon which the entomologists should be directing some of their attention? If we have this information would it not be of help in forest management or in procuring this management where the incentive is lacking, in the maintenance of our forests, even in the control of epidemics?

If these comments upon some features of forest entomological work generally seem to be unduly severe, let me hasten to add that the indictment rests just as heavily upon the forester as upon the entomologist, and perhaps more so, for he has failed for the most part to take into account, fully and completely, the entomological factor. He has thinned improperly, he has cut unwisely, he has not tended to site conditions as he should, he has disposed of his slash when he need not, and not disposed of it when he should. He has signally failed in many phases of management where insects are concerned. In many cases this failure may have been due to economic conditions which he could not control; it is possible that it has been due to ignorance; in some cases it may have been due to a lack of appreciation of the insect problem; in some cases it may have been due to a lack of complete understanding between forester and entomologist.

Too often silviculturists have paid little or no attention to conditions making for the health of the forest, and entomologists have not been in the forefront with their ideas so that silviculturists have adopted them. It would seem that the time is rapidly approaching, if it is not already at hand, when foresters and entomologists must get closer together in research, and in practice; in the establishment and management of sample plots and experimental areas that a complete range of conditions may be covered, and in the management plans and cutting operations of operating units. It is necessary that they work together in thinnings in order to determine proper stand density at different ages, to determine the character of thinning, to determine the effect of removal of various crown classes, to determine the species which should be favored: in studies of methods of cutting to obtain or develop trees that will be immune to attack, or, if not immune, able successfully to overcome the attacking bark beetles: in slash disposal that logging débris may be properly treated; in fire and disease studies that protection against one forest enemy may not develop others or pave the way for their later development; in

studies of growth to know what effect insects have on yields, on stocking, on normality. In management plans and in cutting plans foresters and entomologists must cooperate freely and fully that proper measures may be adopted to control insect pests.

Our forest schools must give greater attention to the subject, and our practicing foresters greater heed. If forest entomology is slighted in the schools, will it not be so slighted or misunderstood in the woods' practice of the future? Entomology should not be taught solely from the taxonomic viewpoint, or solely from the economic. Both features are important and have their place. But, entomology should also be developed from the ecological point of view that proper silviculture may obtain.

Foresters have recognized fire protection; they have not yet recognized insect protection as they should. In fact, forest protection against insects, and against diseases as well, is now in about the same status as protection against fire was in 1910. At about that time protection meant almost entirely the suppression of fires that had already started. Protection today has another meaning — it encompasses not only suppression but also prevention. Current insect protection now is concerned with the suppression of insect attacks and overlooks or minimizes the prevention phase.

It is here my plea that foresters recognize the essential unity of silviculture, that it is so broad enough that it includes the entire field of proper handling of forest lands. It is no less my plea that entomologists recognize the fact that their work is a vital part of silviculture, since entomological control can control or radically modify silvicultural practices. Too often forest entomologists are inclined to forget or neglect the silvicultural phase of their work. It should not be so neglected; it should be the motif of their work.

The familiar motto of one organization could well be applied to forestry work; — "all for one, one for all". If that spirit could dominate the action of foresters and entomologists alike, we would find common meeting grounds, would find closer ties in our work, would sooner bring the day for which we are looking — the day when our forests will be properly and rationally handled.

Two Interesting Neotropical Myrmecophytes (*Cordia nodosa* and *C. alliodora*).

Professor William Morton Wheeler, Bussey Institution, Harvard University, Forest Hills, Boston, Mass.

At the Oxford meeting of the International Congress of Entomology in 1912 I presented a brief account of the bullthorn Acacias of tropical America and their relations to certain ants. I have since had several opportunities to investigate not only these, but also several other famous myrmecophytes belonging to the genera *Cecropia, Tachigalia, Cordia* and *Tococa,* and am endeavoring to summarize our knowledge of all the Neotropical ant-plants and their occupants. For presentation at this time I have selected two species of *Cordia,* namely, *C. nodosa* Lam., which I had occasion to study during the summer of 1920 at the Kartabo Biological Laboratory in British Guiana, and *C. alliodora,* of which I was able to examine thousands of specimens in the Panama Canal Zone during the early months of 1923 and the summer of 1924. These plants are chosen for special consideration, because recently the ant-inhabited cauline swellings of *C. alliodora* have been quite erroneously interpreted by a well-known Genevan botanist, Prof. R. Chodat and his collaborators Vischer and Carisso in their studies of the American species of Cordia (1920).

The botanists have divided the tropicopolitan Borraginaceous genus *Cordia,* which comprises some 230 species of trees and shrubs, into several sections, only two of which, the *Physocladae* and the *Gerascanthus* section, contain a small number of myrmecophytes. The great majority of the species are small trees of ordinary aspect which have nothing to do with ants. In the small section *Physocladae,* two closely related species, *C. nodosa* of Northern South America and *C. hispidissima* of Amazonas and Bolivia, are well-known from the studies of Schimper (1888), Mez (1890), Bailey (1924) and others. They are hairy shrubs or small trees, growing in damp places in the hylaea, or rain-forest. Just below each node, at which the verticillate, rather horizontal branches arise, the stem presents a fusiform, hollow enlargement, or swelling, which opens to the exterior by a preformed orifice. Such a swelling, which has the same fundamental structure in both *nodosa* and *hispidissima,* is known as a myrmecodomatium, because it is regularly inhabited by ants. According to Prof. I. W. Bailey, who collaborated with me in investigating *C. nodosa* in British Guiana, the cavity of the domatium is really formed by the invagination into the stem of one of the lateral shoots "and its formation may be likened to what happens when one

finger of a glove is retracted so that it ultimately projects inwards instead of outwards". This accounts for the fact that the cavity of the domatium is lined with hairy epidermis. No one who has studied the domatia of the *Physocladae* in living plants has ever doubted that they are preformed structures and therefore neither insect nor fungus galls.

The domatia of *nodosa* and *hispidissima* are inhabited by some 21 different species, subspecies or varieties of ants, 11 of which belong to the genus *Azteca*. All of these insects, with a single exception, are small forms which offer but feeble resistance to handling or interfering with the plant. The single exception is *Neoponera unidentata* Mayr., which stings severely, hut makes only small colonies in a few of the domatia and is often absent. Indeed, it nests more frequently in the dead branches of other trees or bushes. The most interesting occupant of the *nodosa* and *hispidissima* domatia is *Allomerus 8-articulatus* Mayr, of which I have been able to recognize four different varieties in different parts of South America. The British Guiana form, var. *demerarae* var. nov. is well-known to the native Indians, who call it the "kurabelli" (Hohenkirk, 1918). Its colonies are extremely populous, comprising thousands of workers and many mother queens. Each colony normally occupies all or most of the domatia on a *nodosa* bush or tree. All the cavities are connected with one another and with the forest floor by a peculiar system of galleries or arcades, constructed by the ants on the surface of the plant and measuring about 5—10 mm in diameter. They consist of minute particles of black, agglutinated earth built up around and supported by the long red hairs that cover the surface of the trunk and branches. A single arcade starts at the ground and ascends the trunk to the first node where it sends a branch along the surface of each limb of the verticel. The branching is repeated at each succeeding node till each domatium is furnished with a gallery that runs up its side and terminates at its orifice. The minute, pale yellow, small-eyed workers are thus enabled to pass under a continuous carton-like roof and between the stiff hairs which support it like so many pillars, from their nests in the domatia to the ground, where they forage among the dead leaves. Coccids *(Pseudococcus brevipes)* are found in some of the domatia, but they are not sufficiently numerous to provide more than an insignificant portion of the food required by so large an ant-population. This consideration and the elaborate construction of the arcades show that while the *Cordia* furnishes most admirable living-quarters for the ants, it is by no means an adequate source of food.

During the rainy season (July to September 1920) I found the cauline swellings full of the kurabelli brood in all stages, together with many males and females. The sexual forms are much larger and darker colored than the workers. The rather peculiar larvae will be described by Dr. G. C. Wheeler in a forthcoming paper. As soon as the domatia on the youngest branches become large enough, deälated females take possession of them and begin, apparently at once, to lay eggs. And though each incipient swelling usually contains only a single young deälated female, I have on several occasions found two, three or even four such individuals, all caring for their eggs or young larvae in common in the same cavity. Unlike most ants, therefore, *Allomerus* is frequently

pleometrotic even during the incipient stages of colony formation. After they are reared, the broods of these young females undoubtedly become a part of the single large polycladic colony which possesses the whole plant.

It cannot be maintained that the kurabelli act as an efficient protective body-guard for the *Cordia,* at least so far as man and the larger animals are concerned. When one handles the plant for some time, the workers do indeed swarm over one's clothes and body and keep on stinging for some time, but their stings are so minute that they produce only a rather unpleasant itching and that only on parts with very thin epidermis. While it is more probable that the kurabelli may be more efficient in keeping the plant free from certain insects, it should be noted that other *Formicidae* not infrequently occupy some of the domatia, though most of them may be tenanted by *Allomerus,* and both Professor Bailey and I sometimes found the foliage of such plants considerably damaged by leaf-cutting ants *(Atta cephalotes).* I have also noticed leaves that had been extensively gnawed by caterpillars, and the foliage of one plant tenanted by *Allomerus* was covered with Cecidomyid galls. The only other insects found associated with *C. nodosa* were termites, which on one occasion were seen to have a gallery extending up the trunk from the ground and terminating in a cauline swelling which they were occupying.

According to Chodat and Vischer (1920) the *Gerascanthus* section of *Cordia* comprises some 17 species. Unlike the *Physocladae,* they are tall shrubs or trees, frequently attaining a height of 20 to 40 feet, with smooth gray bark and coriaceous, opaque leaves, covered with dense stellate hairs beneath and sparser hairs of the same type above. The branching, except in young specimens, is much more obscurely verticillate, and though ant-inhabited cauline swellings occur at the nodes in some of the species, they are much simpler, being merely conical, pyriform or turbinate dilatations of the stem, with large medullary cavity and without a preformed orifice. The flowers are more showy and usually aggregated in broad, dense panicles or corymbs. As a rule, the plants grow on higher ground, in the campos or more open woods and thickets, and therefore in more xerothermal situations than the *Physocladae.*

Chodat and Vischer enumerate 9 of the species of the *Gerascanthus* section as possessing cauline swellings and therefore as being myrmecophilous, but these authors confuse the whole matter by failing to distinguish carefully between galls and preformed domatia. In their opinion, which is based very largely on examination of herbarium material, all the stem swellings are insect galls which are later inhabited by the ants. That this conclusion is eroneous appears from an examination of two species which they fail to distinguish, namely *C. gerascanthus* L. and *C. alliodora* Ruiz and Pavon. The former, which is a large-flowered species of the Greater Antilles, may occasionally have galls, but never has domatia, whereas the small-flowered *C. alliodora,* which ranges from Mexico to Bolivia and Brazil, always has domatia and may occasionally bear galls of the type described by the Genevan botanists. Probably the plant of which I observed all stages in Panama is really a variety of the true *C. alliodora* of Peru. It has been passing as *C. gerascanthus* Jacquinius (nec L.) in the literature, and Chodat

calls it forma *micrantha* of that species. According to Dr. *I. M. Johnston* of the Gray Herbarium *(in litt.)*, however, the Mexican and Central American form should be regarded as a geographical variety (to be named by him in a later publication) of *C. alliodora*. That *C. gerascanthus* and *C. alliodora* must be specifically distinct is clear from the constant presence of domatia in the latter and their complete absence in the former *).

The association of ants with *C. alliodora* has been noticed by several observers. Ruiz and Pavon (1799) refer to it, though they neither figure nor mention the domatia. These structures and their occupants were, however, observed by Spruce (1869) in Brazil, and Beccari (1884) figures a characteristic domatium from a Mexican specimen of the tree. More than 20 years ago Mr. C. H. T. Townsend sent me from Mexico not only specimens of the domatia, ants and Coccids, but also notes on their interrelations. More recently Ule (1907) has made similar observations in Peru and Mann in Bolivia. Menozzi (1927) has also published an account of the domatia, ants and Coccids from material taken by H. Schmitt in Costa Rica. In the accounts of Spruce, Beccari, Ule and Menozzi the tree is cited as *C. gerascanthus* Jacquinius.

I found *C. alliodora* to be a common tree on the Pacific side of the Panama Canal Zone, less common on the Atlantic side near Colon. There are many specimens of it on Barro Colorado Island, in Gatun Lake. From Frijoles to Ancon it is often a conspicuous component of the second growth jungle and in the clearings, but usually avoids moist spots and shows a preference for the slopes of hills. It comes into flower during the last days of February and continues to bloom profusely till about the last of March. During this portion of the dry season the large compact racemes of small white blossoms make the trees conspicuous objects in the landscape. Seedlings and young trees of all sizes can be found singly or in colonies, especially about clearings and along roadsides, so that the plant can be readily studied in all stages. The largest specimens attain a height of 30 or 40 feet. Flowers are not produced till the tree is about 10 or 15 feet high. While young (below 4 to 6 feet) it is usually very symmetrical, with the branches coming off in regular whorls at intervals along the straight, slender trunk, so that in this stage it somewhat resembles adult specimens of *C. nodosa*. Later the branches vary much more in length and direction and are less horizontal. Eventually the crown of foliage may be either irregularly pyramidal or, especially when growing in the open, more diffuse and spreading. The trunk and branches are slender and graceful, with rather smooth, gray bark. The ovate, coriaceous leaves are two to four inches long and grayish green, with rough margins. There is considerable variation, however, in the texture and surface of the leaves. The flowers have a strong odor, somewhat like that of decayed urine. They soon turn brown and persist for some time, often till the middle of April, but later fall off and the same is true of the stems of the inflorescence, though its base, which has a well-

---

*) The detailed discussion of this taxonomic tangle is reserved for my final paper.

developed swelling, or domatium, may remain behind as a dead, dry structure for at least a year.

An examination of fully developed trees shows that there is almost invariably an ant-inhabited domatium at each node and that these swellings grow larger successively the nearer they are to the bases of the branches, but the stoutest branches and the trunk exhibit little or no enlargement in the corresponding regions. Here the domatia persist, nevertheless, but are concealed by a normal and very considerable growth in the thickness of the wood.

It is a singular fact that the adult *alliodora* trees lose their leaves during the rainy season, when all the other trees of the Panamanian jungle are in full foliage. During July and August the bare trunks and branches stand out as if dead among the dense green foliage of the other trees and the very regular arrangement of the domatia at the insertions of the branches are visible from afar. These trees could thus be located with the field-glasses among the tree-tops around the laboratories at Ancon and on Barro Colorado Island.

My attention, like that of Chodat and his collaborators, was at first directed to the inflorescences, by finding distinct elongate thickenings of some of the small flower-stems, and I, too, at first took these thickenings to be the initial stages in the formation of the ant-inhabited cauline swellings. In the former I also occasionally found minute, maggot-like larvae, but did not succeed in rearing the adult insects. They were Hymenopterous and very probably the larvae of the Eurytomid observed by the Genevan botanists, or of some allied species. But most of the enlargements, which are only 2 or 3 mm in diameter, contain no traces of eggs or larvae and are filled with a uniform and undisturbed mass of brown pith. I am certain, therefore, that they are not galls, but merely occasional preformed thickenings of the flower stems, in which the Eurytomids lay their eggs. In other words, these thickenings are strictly limited structures which precede the infection and are not produced by it. The Eurytomid (?) larvae simply feed on the pith which happens to be more abundant in the thickenings than in other portions of the flower stems. That these thickenings do not become the true nodal, or cauline swellings inhabited by the ants, is proved by the fact that they wither and drop off after flowering and cannot therefore produce persistent, leaf-bearing branches. True woody galls are, however, sometimes produced on the twigs of the tree by some unidentified insect, but these galls are very different in shape and texture from the domatia.

In order to ascertain the origin of the cauline swellings it is necessary to investigate the seedlings and young Cordias and the suckers that often grow up from the roots of larger trees that have been felled. These juvenile stages present a very different picture from that described by Chodat and Vischer. The plants are green throughout and actively growing and, as I have stated, very symmetrical in the arangement and length of their few branches. The stem immediately below each of the nodes is regularly swollen and turbinate and forms a rather thin-walled, green capsule, closed on all sides and varying according to its age from 5 to 15 mm in diameter. The delicate remnants of the pith form an even layer over the wall of its large cavity, which contains no

traces of any insect parasite. Nor do the great majority of juvenile trees or suckers harbor any ants till they reach a height of about three to five feet. The swellings are so perfectly regular and symmetrical in their arrangement, so comparable in position with those of the Cordias of the *Physocladae* group and so constantly present, except in the youngest seedlings less than a foot in height and with only the first whorl of leaves, that no botanist, and certainly no entomologists, can possibly regard them as galls. Very occasionally there may be no domatium at a node where it might be expected to appear, but this sometimes happens also in the *Physocladae.* Such infrequent and sporadic failures or inhibitions of development do not invalidate the general conclusion that the domatia of *C. alliodora* are quite as certainly preformed structures as those of *C. nodosa.*

Except in the domatia at the very base of the inflorescence, which, as previously stated, may persist and dry up when the latter falls off, there is a gradual growth in the thickness of the woody walls and in the size of the enclosed cavity. The ants perforate and enter the domatia very soon after their walls begin to lignify. I have not been able to follow the details of the process, although I have frequently found single young deälated females of various species and notably of *Azteca longiceps* Emery either alone or with their first brood of larvae in the swellings. The perforation or perforations, for there may be several, are always made in the thinner portion of the wall below the node, but there is no regularity in their position. In many cases the opening made by the entering queen closes through growth of the plant tissues and has to be reopened by the first brood of workers. The continued growth of the domatium after its occupation must be due to the constant irritation produced either by the ants or by the numerous Coccids which enter it, and attach themselves to the walls of the cavity and sink their delicate mouthparts into the plant tissues. That the Coccids may be the more potent irritants seems to be indicated by the conditions in the various Aphid and Psyllid galls of north temperate regions and the Coccid galls of Australia. In the case of *C. alliodora,* the Coccids may be responsible not only for the irregular shapes assumed by many of the domatia in their later stages, but also for the unequal vigor and growth of the older trees.

That the growth of the domatia does not continue indefinitely is shown in longitudinal sections of the nodal regions of the trunk and larger branches of old trees. The cavity soon ceases to enlarge, but the layers of xylem in its walls increase so enormously that the external swelling is obliterated. Concomitantly with this growth in the xylem the perforations, or entrances to the cavity, develop as long tubular galleries which traverse the whole layer of wood, radiate from the central cavity and open on the surface of the bark at points several inches apart. Although even at this stage the cavities may still be inhabited by ants, the Coccids have all disappeared, probably because their food-supply has been completely shut off by the development of the very thick layer of wood between the cavity and the cambium.

The regular development of the swellings, or domatia in *C. alliodora* and other Cordias with such preformed structures, thus presents a

very interesting problem to the plant-anatomist interested in phylogeny. Attention may be called in this connection to similar structures in at least one other plant belonging to a very different genus, all the other species of which have stems of the normal unswollen type. This is the Polygonaceous genus *Eriogonum,* which comprises about 100 species in the United States west of the Mississippi. The single species, *E. inflatum* Torr., has hollow, fusiform swellings at the upper ends of the internodes of the stems and branches. I have observed this plant at Palm Springs, Cala, in the Mojave Desert, at the foot of the San Jacinto Mts. It is one of the few perennial species of the genus, according to Tidestrom (1925), who cites it as belonging to the "desert areas and hillsides of the Covillea and Artemisia belts" in South-western Utah, Colorado, Nevada, Arizona and California. The swellings are not inhabited by ants, probably because all the *Formicidae* in its desert environment are earth-nesting forms. But there is no doubt in my mind, that if the plant were to invade the tropics, certain species of stem-inhabiting ants would at once take up their dwelling in its hollow swellings. Under these circumstances *E. inflatum* would become a regular myrmecophyte like *C. alliodora.*

During my two seasons in Panama I took pains to collect not only all the ants, but also all the other organisms more or less closely associated with *C. alliodora;* in other words, to make an inventory of the biocoenosis of which the plant is the center or focus. Most of these organisms have now been identified with the aid of a number of specialists, and I am able, in advance of a more detailed account, to make a few summary remarks on the more important *C. alliodora* tenants. Omitting the bacteria, fungi and nematodes, my list comprises 211 different Arthropods, 58 of which are ants. Of this number 48 live in the domatia, two *(Azteca xysticola* and *instabilis)* in the trunk and 8 live in the ground, but visit the foliage for the purpose of attending Coccids, Aphids and Membracids, or possibly in one case *(Atta cephalotes)* for the purpose of cutting the leaves. The great majority of the domatia-tenants occur also in dead twigs of a great variety of trees and shrubs. Probably only four of the species collected, namely *Azteca longiceps* Emery and its subspecies *balboae, cordincola* and *patruelis, A. pittieri* Forel and its var. *emarginatisquamis, Pseudomyrma sericea* Mayr and its var. *cordiae* and *Ps. alliodorae* sp. nov. are to be regarded as obligate tenants of the plant. Of these *A. longiceps* is the most abundant and occurs in about 85% of the domatia on nearly all the trees.

In order to examine the ants and their brood Mr. James Zetek and I adopted a method which we also employed successfully, with obvious modifications, in dealing with other myrmecophytes *(Triplaris, Acacia, Cecropia, Clerodendron, Tillandsia).* We either cut down the tree, or when this was impracticable, lopped off large branches. Then with a pair of strong pruning scissors we cut out the domatia and carried them in cloth bags to the laboratory, where they were placed in a large jar. Some chloroform was poured on the bags and the jar covered till the insects were asphyxiated. The domatia could then be cut open and their contents examined at leisure. We found that few of the ants left their nests to die in the bags and that the domatia, even when

they were inhabited by different species, contained all or nearly all of their original inhabitants.

A number of the *C. alliodora* ants, especially those of the genera *Crematogaster, Leptothorax, Tapinoma* and *Camponotus*, are very sporadic, occuring in only a few domatia on a tree or branch. *A. longiceps* is certainly the common and dominant tenant in nearly all the localities in which I collected. It usually occupies most or all of the domatia, especially those at the base of the branches, while the sporadic species inhabit by preference the terminal and especially the dead and dried swellings that bore the inflorescences of the previous season. Not only *A. longiceps* and *pittieri*, but also several of the other species keep living Coccids in their nest cavities. Unlike the large aggressive Azteca which either construct large pendent carton nests on various trees or form populous colonies in their trunks, *A. longiceps* is a small, timid and rather lethargic ant. This is indicated both by its toleration of other ant-tenants and other insects on the same tree and by the fact that I have sometimes cut up Cordias for hours without being bitten more than half a dozen times by the larger workers. The *A. longiceps* inhabitants of all the domatia on a tree constitute a single polycladic colony, which keeps growing and spreading by successive occupation of new swellings as fast as they attain the proper size on the growing twigs. During March and April the domatia contain much brood in all stages together with many males and winged females. The domatial cavities are lined with a thin layer of brownish or blackish substance and contain a black or dark brown mass of carton, made up of a net-work of trabeculae like those constructed by some other species of Azteca that nest in plant cavities. This structure was seen by Beccari, Chodat and Vischer and Menozzi, and consists of very finely and uniformly triturated and agglutinated particles of wood and pith. I have failed to detect in it any pollen-grains, leaf-fragments or stellate hairs, such as were found by Chodat and Vischer, but would not deny that these substances may sometimes be employed by the ants in the confection of the mass. It is obviously a kind of scaffolding which subdivides the original cavity into smaller compartments and galleries in which the brood can be spread out and more easily cared for. The mass can be readily removed in its entirety, because it is rather feebly attached to the walls of the cavity. Chodat's and Vischer's contention that the ants "dévorent une partie des feuilles et récoltent le pollen" is highly improbable. I have never seen the ants visiting the flowers and they certainly do not devour the leaves. But even if this were true, and if the carton were made of leaf material as these authors maintain, the combined mass of it in all the domatia on a tree would be too small to represent any serious damage to the plant.

In the spaces surrounding the mass of carton and sometimes almost covering the walls of the cavity are the numerous Coccids, among which at least three kinds of species may be readily distinguished. The majority are flat lecanoid forms of a pinkish color and varying considerably in size. Among them may be found small, snow-white Pseudococci, either singly or in clusters and several large, subglobular, shining black or red forms belonging to the genus *Cyclolecanium.* All the Coccids collected on *C. alliodora* by Mr. Zetek and myself were carefully studied by Dr.

Harold Morrison (1929), who recognized 14 species among them. Five (3 species of *Saissetia*, one of *Coccus* and one of *Aspidiotus)* live on the twigs and leaves, but nine (1 *Akermes*, 3 *Cryptostigma*, 1 *Cyclolecanium* and 4 *Pseudococcus)* live in the domatia with the ants. These Coccids suggest interesting problems and reflections. They are present in such numbers that they must provide their hosts with a copious supply of honey-dew. That the large *Cyclolecanium* breed in the domatia is indicated by the fact that they are often found to be filled with eggs and, owing to their size, are quite unable to escape to the surface of the plant through the tenuous openings in the walls of the domatia. But whether the Coccid colonies are originally established by young individuals that crawl into the domatia from the surface of the plant or are carried in by the ants, cannot be decided without further observation. Judging from what is known of some other ants *(Lasius* species, *Iridomyrmex humilis*, etc.), the latter alternative would seem to be the more probable.

There is also in the cavity of each domatium occupied by *A. longiceps* another singular object, which has been overlooked by previous observers. The funnel-shaped lower end of the cavity is filled with a small conical plug of moist substance, which can be readily removed as a coherent mass and on examination proves to have a very complex structure, consisting of the ejected infrabuccal pellets of the ants, moulds, innumerable bacteria and small nematode worms. Its more liquid portion is probably the faeces of the ants and such honey-dew from the Coccids as happens to drain down the walls of the cavity and has not been intercepted and imbibed at its source. We may therefore regard the lowermost funnel-shaped end of the domatial cavity as a veritable public latrine or cesspool. The nematodes have been studied by Dr. Cobb, who informs me that they are unusual from the taxonomic point of view. The moulds and bacteria which flourish in the faecal material of the latrines may afford interesting study for some future student.

Among the other ants of the *C. alliodora* domatia two sluggish and timid species of *Cryptocerus* of the subgenus *Cyathocephalus*, namely *C. pallens* Klug and *C. setulifer* Emery, are of unusual interest. because their females and soldiers have the top of the head developed as a large, broadly elliptical, dish-shaped structure with which they can close the entrance to the domatial cavity. The behavior of these ants is therefore very much like that of the species of *Camponotus* of the subgenus *Colobopsis*. In the latter, however, the front instead of the top of the head exhibits this singular phragmotic modification. Not only is the cephalic dish exquisitely fitted to fill the elliptical nest entrance, but as a result of its long exposure to the elements, the concavity, especially in *C. setulifer*, becomes filled with a compact layer of dust and greenish brown particles that so closely resemble the lichens and algae growing on the bark of the domatium that it is difficult to detect the position of the opening when the soldier or queen is on guard.

If we consider only the Arthropod participants in the *C. alliodora* biocoenose, or community, we have in the following table the numbers of different forms in each of the larger groups:

Arthropoda of the Cordia alliodora Biocoenose.

Hymenoptera (including Formicidae)	69
Lepidoptera	6
Diptera	14
Coleoptera	39
Orthoptera	13
Thysanoptera	2
Neuroptera	2
Heteroptera	10
Homoptera (including Coccidae)	35
Myriopoda	2
Arachnida	18
Isopoda	1
Total	211

Of course, the composition of the biocoenose of a plant so widely distributed as *C. alliodora* must differ considerably in different parts of its range, and, no doubt, the foregoing table, which, apart from the ants, is based almost entirely on collections made in a very limited area, represents a mere fragment of the total Arthropod fauna infesting the tree. It is sufficient, nevertheless, to dispel any notion that the plant must derive some peculiar advantage in the way of protection from the ants that constantly occupy its domatia after it has grown to a height of three or four feet. Before that time and when protection would seem to be most needed it can receive none, as we have seen, because it is not yet inhabited by colonies of ants but only by the solitary queens imprisoned in the domatia. In addition to some insects that visit the flowers, a number of spiders that lurk or spin their webs among the branches and a few beetles that bore in the trunk, the table also includes quite a series of forms which cause serious injury to the most sensitive part of the plant, the foliage. Some of these leaf-eating species may be very briefly considered.

At Ancon no less than six different moth-caterpillars were found by Mr. Zetek and myself devouring the leaves of the seedling and young Cordias, and at least one, the Pyralid *Conchylodes salamisalis* Druce, gnaws great holes in the leaves and with the fragments constructs a very regular, ellipsoidal cocoon. Before pupation it spins a silken tent at the base of the leaf as a temporary retreat. Among the Chrysomelid beetles, the Cassidine *Psalidonota leprosa* Bohem., which in life looks like a large drop of molten gold, passes its entire larval and pupal life on the foliage. Indeed, it is so abundant that *C. alliodora* must be its true host plant. Numerous grasshoppers, especially *Osmilia flavolimbata* De Geer and *Coscineuta coxalis* Serv., both as nymphs and adults, devour the foliage. A small Thrips is abundant on the leaves, which are also seriously injured by an undetermined red spider and all stages of a small Tingitid, *Monanthidia monotropidia* Stål. Another Heteropteron, the Pentatomid *Edessa collaris* Dall., also occurs in numbers and in all stages on the foliage of young Cordias. If we add to these various forms at least 20 different Homoptera, including Membracids, Cicadellids, Jassids, Aphids,

Psyllids and Aleurodids and the 14 species of Coccids, cultivated by the very ants that might be expected to protect the plant, it becomes clear that *C. alliodora* can enjoy no more immunity from insect enemies than any other tropical tree. It seemed to me to be even more heavily infested than many other members of the Panamanian hylaea, but this may have been due to my greater interest in its fauna.

The studies which I hope to publish on the other neotropical ant-plants of the genera *Triplaris, Tachigalia, Cecropia, Acacia, Tococa,* etc., all show conditions very much like those of *C. alliodora.* Each of these plants is the center of a considerable and heterogeneous biocoenose, and in this respect is quite like any non-myrmecophilous plant. I therefore conclude that the usual plant myrmecophile theories which imply survival and the development of domatia, etc., through natural selection are simply "bunk", and agree with Dr. von Ihering when he contends that the myrmecophytes have no more need of their ants than dogs have of their fleas. In the tropics ants are so very abundant and ubiquitous that they will occupy any available vegetable cavities to which they can gain access. Of course, certain species or genera of ants have become hereditarily attached to certain species or genera of trees. When the trees develop nectaries or food bodies in addition to domatia, as in *Cecropia* and the bullthorn Acacias, the relationship established between the trees and the ants is that of host and parasite. In most other cases a similar relationship results from the intercalation of Coccids, which behave like nectaries so far as the ants are concerned. The extraordinary problems of the phylogenetic origin and physiological significance of the domatia, food-bodies and nectaries, however, are purely botanical, and up to the present time we have not made the slightest approach towards their solution.

Literature.

1. Bailey, I. W., 1924. — Notes on Neotropical Ant-Plants. III. *Cordia nodosa* Lam.; in Bot. Gazette 77, pp. 32—49, 2 pls., 5 figs.
2. Beccari, O., 1884—1886. — Piante ospitatrici ossia formicarie della Malesia e della Papuasia; in Malesia II, pp. 1—340.
3. Chodat, R., 1920. — Revision critiques des espèces de *Cordia* appartenent à la section *Gerascanthus* (Cham.) et de quelques espèces du même genre; in La Végétation du Paraguay: Bull. Soc. Bot. Genève (2) 12, pp. 209—218.
4. Chodat, R. and Vischer, W., 1920. — La Végétation du Paraguay, XI Borraginacées: ibid. pp. 157—171, 11 figs.
5. Chodat, R. and Carisso, L., 1920. — La Végétation du Paraguay, B. La Myrmécophilie des Cordias de la Section *Gerascanthus:* ibid. pp. 172—200, 15 figs.
6. Chodat, R. and Carisso, L., 1920. — Une nouvelle théorie de la myrmécophilie; in C. R. Seánces Soc. Phys. Hist. Nat. Genève 37, pp. 9—12.
7. Hohenkerk, L. S., 1918. — Botanical Identifications of British Guiana Trees and Plants; in Journ. Board Agric. Brit. Guiana 11, pp. 98—106, 178—185.
8. von Ihering, H., 1907. — Die Cecropien und ihre Schutzameisen; in Engler's Bot. Jahrb. 39, pp. 666—714, 5 pls., 1 fig.
9. Menozzi, C., 1927. — Formiche raccolte dal Sig. H. Schmidt nei dintorni di San José di Costa Rica; in Ent. Mitteil. 16, pp. 266—277, 336 bis 345, 9 figs.
10. Mez, C., 1890. — Morphologische und Anatomische Studien über die Gruppe der Cordieae; in Engler's Bot. Jahrb. 12, pp. 526—588, 2 pls.

11. Morrison, H., 1929. — Some Neotropical Scale Insects associated with Ants; in Ann. Ent. Soc. Amer. 22, pp. 33—60, 9 figs.
12. Ruiz, H. and Pavon, J., 1799. — Flora Peruviana et Chilensis. II. p. 47 Pl. CLXXXIV.
13. Schimper, A. F. W., 1888. — Die Wechselbeziehungen zwischen Pflanzen und Ameisen im tropischen Amerika. Jena, G. Fischer, 95 pp. pls.
14. Spruce, R., 1908. — Notes of a Botanist on the Amazon and Andes. Edited by A. R. Wallace; 2 vols. London, Macmillan.
15. Tidestrom, I., 1925. — Flora of Utah and Nevada; in Contrib. U. S. Nat. Herbarium, Vol. 25.
16. Ule, E., 1907—1908. — Die Pflanzenformationen des Amazonas-Gebietes. Pflanzengeographische Ergebnisse meiner in den Jahren 1900—1903 in Brasilien und Peru unternommenen Reien; in Engler's Bot. Jahrb. 40, 1907, pp. 114—172; 1908 pp. 398—443, 8 pls.

The Economical Value of Ants for our Forests.

Dr. H. Eidmann, Institute of Forestry, University, München, Germany.

As is well-known, ants hold a prominent position in the world of insects on account of their social life, by reason of which they are of high importance in the biocoenosis of the forests almost everywhere in the world. This is still very often not fully appreciated.

Few species of ants are injurious. With us in Germany we may place into this category the species of *Camponotus*, which, though building their nests mostly in rotten wood, sometimes attack also the trunks of perfectly sound trees. They prefer coniferous trees, especially pines. By their boring activities trunks may be rendered hollow up to a heigth of ten metres. The construction of their nests is very peculiar, for the hard portions of the annual rings remain intact and only the soft parts are hollowed. In this way apartements, concentrically arranged, are achieved; nothing but the centre of the trunk is hollowed, while most layers of the peripheric wood remain uninjured. By such nests the trunks get weakened and reduced in value, and are severely exposed to the danger of windbreak; more over, woodpeckers are attracted to them and, in order to get at the ants, very often peck immense holes which unite channellike. Our species of *Camponotus* can also become dangerous by their kind of nutrition. In spring they often cut off fresh shoots of oak in order to suck the sap that is exuding and, besides, their rearing of plant-lice is injurious. Some species of ants, for example *L. niger, F. fusca* and others, prefer to build their nests in the rotten wood of old stumps of trees which they hollow out inclusive of the bark. But I have found them neither in the wood nor in the bark of sound trees. On the whole we may say that there is hardly any considerable damage done by ants in our forests.

On the other hand, the utility of ants is much greater. Especially *Formica rufa* (and its races) is of the greatest importance for keeping our forests in a sound state. Being an insect of prey it feeds almost entirely on other insects, which it usually seizes alive according to my experience gathered in the hunting grounds of the colonies of Red Hill Ants. During these last years I made statistical inquiries on a larger scale in Germany; up till then there existed no exact investigations as to the food of the Red Hill Ant, the utility of which has often been disputed. We took the prey from the worker ants returning, laden with prey, to their hills at different times of the day, afterwards examining the prey carefully. This showed that about half of the classified insects were noxious insects and only about one sixth useful ones. These the ants cannot seize so easily because of their swiftness and capability of defence. Calculations referring

to the number of the insects brought home by the ants showed that about two million insects were destroyed in one summer by a large colony of this ant. The hunting grounds of the colonies of ants are very vast; in some cases they extended over an area of 17½ acres. So you see that the Red Hill Ant is an extremely useful insect. We must not undervalue its importance for keeping our forests in a sound condition, especially for preventing insect pests. This became highly evident during the great Pine-Moth pest in Northern Germany in 1924, when about 375,000 acres (that is about 586 square miles) of forest were totally destroyed. Wherever there had been ant hills the forest remained uninjured to a greater or smaller extent. These "Ameisenhorste", the tracts prevented by the ants from being destroyed, varied in size up to the extent of 5 acres, and these intact spots, peeping out like green oases from their bare and destroyed surroundings, are just excellent starting points from which to begin the re-afforestation of the damaged districts and for natural restoration. It is very significant that no ant hills existed in the vicinity of the forest which was ruined. Thus the ants of prey are one of the most important elements in keeping the balance in the biocoenoses of our forests, and they should be protected as much as possible.

Influence of Temperature on the Number of Eggs in Lepidoptera.

Dr. H. Eidmann, München.

My investigations were made with a view to discover whether the number of eggs of insects is influenced by different degress of temperature while the insect in question is developing. These investigations I confined to Lepidoptera, and I also examined very closely the morphological state of their female genital tract.

Contrary to the opinion of most authors it appears that the Lepidoptera when coming out of the pupa have nearly always still a great number of undeveloped eggs in their ovaries and that such eggs are developed postmetabolically and become fit to be deposited. If the female butterflies do not copulate, they generally deposit only part of their developed eggs, while copulated butterflies will deposit all of them. However, in many cases the latter still retain a great number of undeveloped eggs in their ovaries which will ripen under certain conditions, thus increasing the number of eggs produced and so augmenting the capacity of reproduction of the species in question.

In copulation one or more spermatophores are deposited in the bursa copulatrix, but it appears that already during copulation the sperm gets into the receptaculum seminis. At the same time not only the proper receptaculum is getting filled with sperm, but also the reservoir of the accessory gland, provided such exists. The excretory duct of the recepta-

culum is mostly furnished with a special locking-apparatus. We may assume that the fecundation of the egg always proceeds from the receptaculum.

In most species the colleterial glands show a very varied development of the reservoirs. With such species as possess an ovipositor capable of being protruded there exist special means by which the colleterial glands may be elongated a great deal.

In order to examine the influence of temperature during development, various cultures of chrysalids of butterflies were exposed to normal temperature as well as to heat and cold. Although this problem could not yet be altogether solved, it seems to me that as a rule such insects as originate in the cold deposit fewer eggs and such as originate in the warmth deposit more than those females which spring from normal cultures. The result is of great importance in explaining the cause of insect pests. Statistical examinations on the gradation of the Pine Moth in Germany during the last century made in our Institute have proved that there has always been an unusual number of these moths in especially warm years. Certainly the increase in the number of eggs through warmth and the augmentation of the capacity for reproduction of the noxious insects do much towards producing pests. It seems to be of importance that parasitized chrysalids die at high degrees of temperature, which fact I was able to ascertain during my investigation. By these means the natural enemies of the moth may be diminished under certain circumstances. But these two elements are certainly not the only ones necessary to produce a pest, for according to our present-day knowledge the reasons which cause gradations are extremely complicated.

The Share of the Netherlands in the Development of Entomology in Past Centuries.

J. B. Corporaal, Zoological Museum, Amsterdam, Holland.

The Netherlands (or Holland) are a country which from oldest times, through its highly developed commerce, has come into contact with all the then known faunas and floras of the earth, and from the earliest times our sailors have brought home all sorts of strange and interesting specimens of the three realms of nature.

Although the old merchants did not deem it appropriate to give very accurate information regarding their means and ways of communication, our mercantile marine, always in want of hands, sailors, and of marine surgeons, offered wide possibilities for people, of other nations too, who wished to see the world.

Moreover, the comparative freedom of thought and of the press, which, from the beginning of the seventeenth century, was prominent in our institutions, gave occasion for printing and for distributing many scientific works, among which were several on Natural History, including Entomology.

The very beginning of entomological publications in the Netherlands were the small picture-, or rather engraving-books by George Hoefnagel (1545—1617) and by Wenzel Hollar (1607—1677), who were only delineators, and gave no descriptions or references.

The first entomological publicist in Holland was John Goedart, (1620—1668) also a painter, who often made correct observations, but nevertheless was still a believer in spontaneous generation.

The development of dioptrics in the Netherlands then made it possible for the great figures of Johan Swammerdam (1367—1685) and Antonie van Leeuwenhoek (1632—1723) to make their path-breaking observations with the help of strong magnifying glasses, and even with compound microscopes. Van Leeuwenhoek denied categorically the possibility of spontaneous generation.

Pieter Lyonet (1706—1789) counted in the larva of *Cossus cossus* L. 4041 muscles, while at that time the number of muscles in the human body was held to be 529. He was a friend of the illustrious French observer R. A. F. de Réaumur, as is shown in Mr. Wheeler's recent, very interesting book "Natural History of Ants", pp. 125 and 214.

Réaumur's works, as well as those of Redi, Harvey, Vallisnieri, were reprinted in Holland. Harvey, though not exactly an entomologist, had however great influence on the way of thinking of

the zoologists in general. I mention his name chiefly to illustrate the above by the fact that his famous work "De generatione" was translated and reprinted no less than five times in Holland, in the year of its original publication. In those years such an action was not censured; copyright did not exist; on the contrary, it was generally appreciated that these cheaper editions made the works more universally accessible and known.

Our oversea-trade gave our universities the opportunity to draw scientists and students from a wider area than the older, and deservedly famous, Italian academies. This crowd of students explains to some degree the necessity for so many reprints. Many foreigners came to Holland to acquire their degree, which was encouraged by the low costs of graduation, and by the presence of famous scientists, such as Clusius and Boerhave. Letters addressed simply "Boerhave in Europe" reached their destination without mistake.

George Marcgraf, from Liebstadt (1610—1644), and Maria Sibylla Merian (1647—1717), could accomplish their studies on the insects of Brasil and of Surinam under the protection of our government. They were among the first biologists who reported on American insects.

Jacob L'Admiral (1700—1770) was the possessor of a large "cabinet", as a biological collection was then called. In his publications he was a forerunner of Linnaeus.

The founder of modern systematics, Carolus Linnaeus, came to Holland, to Harderwijk, to obtain his degree of doctor. This explains why the first edition of his "Systema Naturae" was printed in Holland, at Leyden, by Theod. Haak. His work and ideas were not generally appreciated then in Europe, but in Holland he found the occasion to test his ideas and his system in the many natural history cabinets, and here he also found the patron (Cliffort) who gave him financial support, after Gronovius and Lawson. In Holland was the scientific atmosphere where the importance of his doctrines was recognized and appreciated.

When in his native country Linnaeus had reached his high position, and had succeeded in getting his pupils sent out to all parts of the world for further studies and for collecting material, he often called in the good offices of Holland's mercantile marine to reach his ends. So his pupils, e. g. Sparmann and Carl Peter Thunberg, could visit a large part of the world.

Through our navigation, too, we were the furnishers of curiosities to the many cabinets which were then in vogue in Europe, many of these curiositios being entomologica and other zoologica.

One of the most renowned entomological cabinets of our country was that of the two Voets, father and son. Johannes Eusebius Voet, the son (deceased 1778), had already specialised in Coleoptera so much that, when he had reared a hermaphrodite of a lepidopteron, *Lymantria dispar* L., he gave it to Jacob Christian Schaefer, of Regensburg, who described it in his publication on the "Eulenzwitter.".

Pieter Cramer (end of the XVIII. century) also possessed an important entomological cabinet, and in a large 4° work with 400 plates gave many descriptions of exotic Lepidoptera, several of which were from North America.

Christian Sepp, originally a copper-engraver, of the same period, made a special study of the early stages of Lepidoptera, and started his large work, to this day very highly esteemed, under a title, typical for that period, of which the translation runs: "Contemplation of the wonders of God in the least esteemed creatures, or Netherlands Insects, in their remarkable house-keeping, marvellous transformation and other interesting particularities, described from own observations, accurately drawn from life, engraved on copper and coloured by Christian Sepp." 1762. The first 30 plates are by himself alone. The work was continued by his son and his grandson and by further descendants, in collaboration with other entomologists. It is being continued still. I am happy to be able to show you the last part, which appeared this year, from the pen and the pallette of Dr. A. Brants, honorary member of the Netherlands Entomological Society and the nestor of our entomologists. The complete work, with all the continuations, now comprises over 600 plates, and about 3000 pages of text, in 13 volumes.

Carl de Geer (1720—1778), whose family originated from Holland, where the family is still in existence, had of course many relations in our country and has made many of his studies and experiences when he was a student in Utrecht.

The occupation of our country by the French in the beginning of the XIX. century brought with it a general downfall, in scientific as well as in other spheres.

The revival started with faunistic explorations of our own country, which are of lesser interest for the general entomological public.

Then followed, in 1845, the establishing of our Entomological Society, in seniority the fourth of the world. Initially the activities of our society were chiefly directed to the study of our indigenous insects, but very soon many of the members sought to enlarge the sphere of their interest. Many exotic insects, principally of the Indo-Australian Archipelago, were described by S. C. Snellen van Vollenhoven, F. M. van der Wulp, J. C. H. de Meijere, W. de Haan, G. van Lansberghe, J. R. H. Neervoort van de Poll, H. Albarda, C. Ritsema, R. van Eecke, P. C. T. Snellen, A. C. Oudemans, and many others.

We owe many biological observations to J. Th. Oudemans, now President of the Netherlands Entomological Society, who also published a manuel on the insects of the Netherlands, to A. J. van Rossum, J. C. H. de Meijere, A. Brants, etc., on tropical insects to M. C. Piepers, S. Leefmans, W. Roepke and E. R. Jacobson. One of our most distinguished economic entomologists was Prof. Ritzema Bos, recently deceased.

I hove to have shown that from very early times the Netherlands have produced many entomological students whose works are being consulted even to-day. It has been for me a pleasant and patristic task to call up the remembrance of their names and works. I will not, of course, expatiate on the present generation of Netherlands Entomologists, but I hope and trust that their work, both in Europe and in our colonies, will prove to the entomological public that they are no unworthy successors of their meritorious predecessors.

Carbohydrate Metabolism in the Honey Bee Larva.

Dr. E. Ronzoni and Dr. G. H. Bishop, Departments of Medicine and Physiology, Washington University School of Medicine, St. Louis, Mo.*).

The honey bee larva ingests a large amount of carbohydrate as honey, and stores it, chiefly in the so-called fat body, to be used in pupal growth. The purpose of this paper is to present data as to the form and the quantity in which this carbohydrate is stored, and to correlate this storage and subsequent utilisation with the insect's development, and especially with such physiological changes as are known to occur during the development. Certain phases of physiological activity in this larva have been investigated previously, with special reference to the cytology of the fat body (Bishop, 1921—22, 1923a), and to the physical and chemical properties of the body fluid (Bishop, 1923, Bishop, Briggs and Ronzoni, 1925).

In obtaining blood, the larvae were removed from the comb without injury by means of a fine forceps, traces of food materials adhering were blotted off with filter paper, and a puncture was made into the dorsal lymph space, the carcass being then laid on the edge of a funnel on its back and allowed to drain for about two minutes, the blood falling into an iced tube. Since such food material as might still adhere would contain sugar, some samples were taken up in a medicine dropper as the fluid oozed from the puncture, without appreciable contact with the outside of the larva. No significant contamination by the first method was indicated. The carcasses were then placed in a second iced container, and used for glycogen determinations of whole larvae. About forty worker larvae were required per cc. of blood, fifty for the later stages, and one half to three quarters of an hour was required to obtain such a quantity of fluid. Blood from the pupae was centrifuged to throw down tissue cells; for though care was taken not to squeeze the pupae enough forcibly to express the histolysing tissue, many cells are free in the blood at this stage. Further fluid draining from the carcasses in the container was centrifuged, and determinations made on cells and fluid separately. The significance of these procedures will appear below.

All material was obtained from strong hives of bees at the height of the white and sweet clover honey flow, during warm weather, when brood

---

*) Much of this work was carried out in the summer of 1926 in the biochemical laboratory of the University of Michican School of Medicine, and our thanks are due to Dr. Lewis and his staff for assistance and courtesies in putting at our disposal a laboratory and chemicals near the large supply of biological material available to us in Ann Arbor.

rearing was at a maximum, but collections were made early in the morning before the day's honey was coming in.

The stages studied are (1) mature feeding larvae, just before sealing up of the wax cell, when food material is being actively ingested, (2) the spinning larvae, sealed up and performing the only significant muscular work involved in the developmental cycle, (3) the prepupae, a quiescent stage in which histological breakdown of the storage tissue takes place, releasing food materials into the body fluid, and (4) the pupae, in which growth of mature insect tissue takes place at the expense of stored nutriment.

The modified Shäffer-Hartmann method (Somogyi, 1926) was used for sugars, the different components being isolated as described below. All carbohydrates were determined as glucose. Part of each sample was allowed to be acted upon by yeast (Somogyi, 1928), the reducing component not so abstracted being referred to as reducing non-sugar. This component is subtracted from each final value of carbohydrate. Different reagents allow different amounts of reducing non-sugar to pass into the filtrate, a little being present in the Folin-Wu filtrate, much more after hydrolysis, and mercuric nitrate precipitation yielding very little. Glycogen was estimated after treatment of the material with alkali which destroys sugar, precipitation by 66% alcohol, and hydrolysis by half normal HCl after neutralisation, and was determined as glucose, or by weighing before hydrolysis. Such precipitation brings down much that is not glycogen, unless the solution is very dilute to start with, but this material is not reducing, even after hydrolysis.

Carbohydrates found may be designated as follows: free sugar determined as glucose, in the blood and possibly some in the cells; combined carbohydrate, part of which consists of polysaccharide below glycogen and part combined with protein as "proteinic sugar", in the blood; and glycogen, laid down exclusively in the cells, but released into the blood at late stages of histological breakdown. The combined carbohydrate listed is derived by subtracting from the total carbohydrate less reducing non-sugar both the glycogen and free sugar less their reducing non-sugar concommittants. Its products after acid hydrolysis are promptly abstracted by yeast. It is not maltose, which has half the reducing value of glucose, for there is so large a quantity left in late stages that the "free sugar" then present (as low as 30 mg. %) is only a small fraction of the value corresponding to that quantity of maltose, even if no glucose were present at all.

A sample of larval blood containing no glycogen was investigated by Dr. Somogyi (technique as yet unpublished) with a view to determining whether maltose or sucrose were present. The procedure depends on the circumstance that, from a suitable concentration of carbohydrate, washed yeast will abstract all glocose and sucrose in five minutes, and maltose only after one half hour. After an hours action by yeast, the polysaccharide and proteinic carbohydrates were not appreciably reduced in amount, indicating that neither sucrose nor maltose were present.

The Table (p. 364) presents carbohydrate data (checked by many other experiments) from one fairly complete experiment which included two stages

of material, 1 and 3. In "free" and "combined" sugar, the latter including in these tables both that combined with protein and the free polysaccharide, the decrease at stage 3 is not wholly to be atributed to muscular or other metabolic activity of the larva, because, while the glycogen content of the whole larva reaches a maximum at this period, the fat content may still be increasing (Straus, 1911), presumably at the expense of the nonglycogen carbohydrate. Straus shows that during pupation the carbohydrate stores are depleted first, the fat decreasing more slowly. Other experiments indicate that the free blood glucose values for later stages approach those for the starving mammal, while the low respiratory quotients obtained in insect pupation suggest that the reserve fat is utilised later than carbohydrate.

The data labelled "cell glycogen, sugar", etc., are from material centrifuged out of the blood of the late stages, where the tissue is histolyzed to such an extent that clear fluid is not obtained by puncture of the larvae. The "total glycogen" is that determined upon the carcasses from which the corresponding blood was obtained, to which has been added the glycogen of the blood and of the cells centrifuged from it, and is thus total glycogen per total weight of the larvae, including blood. Determinations were made on fractions of combined samples of 75 to 125 animals, thus averaging out individual differences. The glycogen totals are practically the same as those of Straus for the same stages.

From the data of Straus (l. c.) and those presented here we may summarize the facts of sugar and fat storage and use for the developing bee larva as follows: During the very rapid increase in weight of the last day or more of larval life, the large quantities of carbohydrate ingested are partly changed to fat and glycogen, and partly remain as free and combined sugar in the blood (700 and 3,000 mg. per 100 cc. blood). During the muscular activity of spinning, reflected in the increased CO_2 output, this blood reserve is drawn upon, but part of it even after cessation of feeding is still being converted into fat (and possibly into glycogen). There is no glycogen in the blood until a still later stage when the cells of the fat body break down. On the other hand, both the monosaccharide and other sugar are lower in the cells than in the blood of these later stages, while the glycogen is much higher. We may infer that glucose (or a similar simple sugar) is the labile form in the blood; that the combined sugar and polysaccharide are a blood carbohydrate reserve, the glycogen a cell carbohydrate reserve, which is released into the blood as its sugar reserve is used up. Presumably the blood sugar enters the cells as glucose, to be transformed inside them to glycogen or fat. The animal uses first, or preferentially, the simple free sugar, until its concentration falls to a low value; both for metabolic function and for storage in more stable forms; then the higher carbohydrate is drawn upon, and, possibly, finally the fat, as a source of carbohydrate for tissue growth.

In a previous communication (Bishop, Briggs and Ronzoni, 1925), the lowering of the freezing point of this blood which could be assigned to known constituents was compared with the actual lowering observed at different stages. The higher sugars were not then known to exist in this blood. The change in carbohydrate with pupal metabolism

in a large degree explains the reduction in the osmotic pressure at this stage. If all the carbohydrate lost were computed as disaccharide, its osmotic effect (= . 108° C) just compensates for the difference observed (. 11° C). However, the osmotic constituent represented by higher carbohydrates cannot be accurately computed thus, since it exists in a more complex form than a disaccharide.

In this connection it is worthy of note that the transformation of metabolic material is such as to favor a fairly constant osmotic pressure. The blood reserve of sugar allows a more rapid assimilation of carbohydrate than would be possible with glucose, without a marked increase in osmotic pressure, and the large volume of blood at this stage seems to be a further means of keeping the concentration down. This volume decreases during pupation as its solids are utilised, the actual dehydration apparently keeping pace with disposal of solids. S t r a u s (l. c) notes that the water percentage of the whole animal decreases toward the end of larval life, then increases again during pupation, but he fails to correlate this fact with the percentage of fat at corresponding times. It is obvious that fat is a means of food storage that spares water, and thus affords an economy of space in the storage tissue. The actual hydration of tissue turns out to be much more constant than S t r a u s's figures for total water percentage would suggest.

Table. Blood & Tissue Carbohydrate, Reducing non-sugar deducted.
mg. per 100 cc.

	Average Wt. per larva mg.	Free Sugar	Combined-sugar + polisac-charide	Glycogen	Total CH	Total Glycogen in larva	Glycogen per larva mg.
			2.785		3.470		
Stage I	120	685	3 035	0	3.720	6 450	7·7
Stage III	118	154	1.806	2.800	4 760	6.000	
Cells from III		130	680	8.000	8.810		
Fluid from carcasses centrifuged Stage III Cells from above		164	1.726	4.370	6.260		
					7.875		

E x p l a n a t i o n o f T a b l e. — Data from one collection of blood from each of two stages from the same colony, in quantity sufficient to make all determinations on fractions of the same sample with satisfactory duplicates. The cells centrifuged from stage III are seen to contain much more glycogen and less of other sugars than the fluid. The second sample of fluid obtained after greater disturbance of the tissues shows 1500 mg. percent more glycogen free in the fluid than the sample drained out with the minimum disturbance of cells. The blood of the first two stages contains no detectable glycogen; less than 10 mg. percent. The free sugar in the fourth stage blood falls to between 80 and 20 mg. %.

Literature.

1. Bishop, G. H. — 1921—22; in Journ. Morphol. XXXVI 567.
2. „ „ „ — 1923a; ibid. XXXVII 533.
3. „ „ „ — 1923b; in Journ. Biol. Chem. LVIII 543.
4. „ „ „ A. P. Briggs and E. Ronzoni, 1925; in Journ. Biol. Chem. LXVI 77.
5. Somogyi, M. — 1926; ibid. LXX 599.
6. „ „ — 1928; ibid. LXXVIII 117.
7. Straus, J. — 1911; in Zeits. Biol. LVI 347.

The Present Status of certain Insect Pests under Biological Control in Hawaii.

O. H. Swezey, Entomologist,
Experiment Station of the Hawaiian Sugar Planters' Association, Honolulu, Hawaii.

Perhaps it is generally known that in the Hawaiian Islands remarkable success has been attained in the control of insect pests by the introduction of their natural enemies from other countries. As in many other places, so in Hawaii the worst pests are not native insects, but introduced species that have gained admission in some way through the channels of commerce. We have had a number of very destructive ones in Hawaii. The work of the entomologists in searching for natural enemies in the homes of these pests and their introduction to Hawaii began in 1893 by the employment at that time of the late Albert Koebele for this purpose. As a matter of fact, one very valuable lady-beetle had been introduced before that time by Mr. Koebele, namely *Novius cardinalis* Muls., in 1890, after it had become established in California as an enemy to the cottony cushion scale (*Icerya purchasi* Mask.). This lady-beetle proved as successful in Hawaii as it had in California in controlling the cottony cushion scale. This pest was very severe on fruit trees and ornamental trees and shrubs before the establishment of the lady-beetle. It was soon brought under control, and for a long time now has not been of any importance as a pest. Its present status is that it maintains its existence, and small colonies are occasionally met with which are soon destroyed by the arrival of the lady-beetle. Serious injury is done only in cases of isolated, very small trees, as young seedlings becoming infested, or young nursery stock, in which cases the small plants may be badly injured by the cottony cushion scale before the lady-beetles increase sufficiently as to reduce the pest colony.

1. Sugar-Cane Leafhopper, Perkinsiella saccharicida Kirk.:

The most destructive pest in Hawaii has been the sugar-cane leafhopper. It was most probably introduced from Australia in imported cane cuttings for planting more than 30 years ago. By 1902 it was attracting attention in all the sugar cane districts of the Islands and causing considerable alarm. By 1904 it was causing an estimated loss of $3,000,000.00 annually, and threatening the sugar industry with ruin. Parasite introduction began the previous year. The successfully introduced parasites were as follows:

Egg-parasites: *Paranagrus optabilis* Perkins, Queensland, 1904.
Paranagrus perforator Perkins, Queensland, 1904.
Anagrus frequens Perkins, Queensland, 1904.
Ootetrastichus beatus Perkins, Fiji, 1905.
Ootetrastichus formosanus Timb., Formosa, 1916.
Dryinidae: *Haplogonatopus vitiensis* Perkins, Fiji, 1906.
Pseudogonatopus hospes Perkins, China, 1907.

Egg-sucking bug: *Cyrtorhinus mundulus* Bredd., Queensland and Fiji, 1920.

Of the earlier introductions, the egg-parasites were the most effective and of them *Paranagrus optabilis* the best of all. With their establishment, together with the help of quite a number of native parasites and predators, the leafhopper pest was gradually reduced so that by 1917 in most plantations very little damage was done by leafhoppers. A few plantations were still suffering considerably. After the establishment in 1922 of the *Cyrtorhinus* bug which sucks the eggs, the pest was still further reduced, so that finally it was under complete control.

The present status of the leafhopper is that it is very scarce and hard to find in most of the sugar cane area. In an occasional instance they become noticeable, but not abundant enough to be injurious. Their enemies, especially the *Cyrtorhinus* bug, soon appear and increase so as to reduce the pest again to scarcity. A great deal of work is being done in the propagating of seedling varieties, and occasionally a few among these seem more susceptible to leafhopper, or at any rate they may become more conspicuously populous with leafhoppers than the others. At times, too, the leafhoppers become more numerous in fields of cane that are affected with the "eye-spot" disease.

At the present time, it is the usual condition of the cane to be free from the honeydew of the leafhopper; whereas, in the years when the leaf hopper pest prevailed, the cane was always sticky with honeydew and the leaves covered by sooty mold which flourished in the honeydew. It was impossible to enter a cane field without at once becoming messed up with this honeydew and black mold. Now, one encounters no such difficulty, for the cane leaves are usually clean.

2. The Sugar-Cane Weevil Borer, Rhabdocnemis obscura (Boisd.):

This cane borer has for a long time been an important pest. It was known as a cane pest as long ago as in the '60's, and is thought to have been introduced from Tahiti with cane cuttings for planting at an earlier date. It became generally dispersed throughout the Islands and in some places wrought great havoc in the cane fields. Sometimes fields of cane would be half destroyed. Various practices were made use of to try to check it, but with little effect, and there was an annual loss that must have amounted into the millions. However, after the New Guinea Tachinid (*Ceromasia sphenophori* Vill.) was discovered, and introduced in 1910, there began to be a reduction in the number of borers, and a consequent reduction of the loss of cane by them. In one of the plantations that was most subject to losses by the borer, in three years the number of in-

fested canes fell from 30 to 12.77%, with a resultant increase of about 7 tons of sugar per acre, or about 1400 tons of sugar for the whole plantation annually, equivalent to a saving of more than $100,000.00. On another one of the worst borer-infested plantations, in four years, due to the reduction of borer damage, the yield of sugar per acre increased by 2 tons, or a saving of nearly $100,000.00 to the plantation. Conditions continued to improve until now, after 18 years, the loss by borer is negligible for the greater part of the sugar-cane area. There still are borers on all of the plantations, but on those so situated as to be the least favorable to the borer, the parasite keeps them reduced to such scarcity as to be ignored. In other situations their numbers increase, even up to an infestation of 30% of the canes. This does not mean a loss of 30%, for many of the infested canes are not entirely destroyed, but still are of some value for sugar. Usually, nowadays, these most severe borer infestations are where there is a great growth of cane of two years' growth or more, and much of it decumbent and buried by the fallen dead cane leaves, so that the borers in these canes are where they cannot be reached by the parasites, hence can increase in numbers unchecked and with a consequent increase in injury to the cane. So that, although there is an enormous saving due to the work of the parasite in checking the borer, the latter still causes thousands of dollars losses to some of the plantations. The estimate last year on one of the plantations having the greatest borer damage was a loss of $200,000.00. On the other hand , when examining the borer injury, or hunting for borers in most regions, the borers are nearly all found to be parasitized, fully demonstrating the value of the parasite in controlling the pest.

3. Cane Rootgrub, Anomala orientalis (Waterh.): This pest made its appearance in cane fields as recent as 1912. It spread from one locality until it was causing a loss $50,000.00 annually to two plantations partially infested by it, before its spread was checked by an introduced parasite, when it was reduced to harmless numbers. The parasite in this case was a digger wasp (*Scolia manilae* Ashm.), from the Philippines, which was introduced in 1916, and soon increased rapidly, destroying the grubs and checking the spread of the pest, so that within two years the damage done by them had been reduced to insignificance. Now a specimen of either the grub or beetle is seldom found. Thus was checked a pest that otherwise would have become spread throughout the cane area on the island of Oahu, and no doubt eventually to the other Islands.

4. Armyworms, Cnirphis unipuncta (Haw.) and Spodoptera mauritia (Boisd.):

There have been outbreaks by these two common armyworms, usually annually for many years, especially in those sugar plantations situated adjacent to grasslands, or having fields infested with nutgrass, which is the favorite food of *S. mauritia*. Parasites have been introduced at various times and from various places, until now armyworms are so well controlled that outbreaks seldom occur on most of the Islands, and not so often or so extensive on the island of Hawaii, where these outbreaks have been the most prevalent. This has been the case especially since the introduction from

Mexico in 1923 and 1924 of *Euplectrus platyhypenae* Howard and *Archytas cirphis* Curran. Other valuable parasites working on armyworms here are: *Amblyteles koebelei* (Swezey), *Amblyteles purpuripennis* (Cress.), *Hyposoter exiguae* (Viereck), *Chaetogaedia monticola* (Bigot) and *Frontina archippivora* Will., all from California, and an egg-parasite, *Telenomus nawai* Ashm. from Japan.

5. Grey Sugar-Cane Mealybug, Pseudococcus boninsis (Kuwana):

This mealybug is so completely controlled by *Pseudococcobius terryi* (Fullaway) as to be rarely met with. This parasite does not attack the pink sugar-cane mealybug, *Trionymus sacchari* (Ckll.), and this mealybug is found generally prevalent in all cane fields, though not rated as a serious pest. A number of lady-beetles that feed on mealybugs have been introduced, but they do not feed to any extent on the pink sugar-cane mealybug.

6. Avocado Mealybug, Pseudococcus nipae (Mask.):

Introduced lady-beetles fed on this mealybug to some extent, but apparently exercised no control. Avocado trees always had the leaves badly covered by this mealybug. The insect also badly infested fig, mulberry, guava, coconut and some other trees as well. Finally the little parasite *Pseudaphycus utilis* Timb. was introduced from Mexico in 1922. It quickly became established and spread throughout Oahu, and was distributed to the other Islands, where it spread similarly. In about two years the avocado mealybug was practically exterminated. The leaves of avocado now remain clean, as do also the leaves of the other trees mentioned that were formerly infested by *nipae*. No infestations are found on any of these trees. It has been a most remarkable case, both as to rapidity of spread of the introduced parasite, and the completeness of its work on the host insect.

7. Cottony Mealybug, Pseudococcus filamentosus (Ckll.):

A parasite was introduced for this mealybug in 1925, from Hongkong. It is *Anagyrus dactylopii* (Howard). It readily became established, and the mealybug has become scarce. Possibly it may become as well controlled as is *P. nipae*.

8. Plant Lice:

A number of the common plant lice have been troublesome in the past, and quite a number of lady-beetles and other enemies have been introduced at various times. At present all of these working together seem to keep most plant lice from becoming serious. Often there may be an outbreak which appears serious for a time, but the lady-beetles and other Aphis enemies soon find them and quickly check and eliminate the pest. Probably the plant lice are as well controlled in this way as in any other country. Seldom does anyone practise spraying or dusting for these outbreaks of plant lice.

9. Mediterranean Fruitfly, *Ceratitis capitata* Wied.:

This pest made its appearance in 1910 and soon became generally spread, severely attacking nearly all kinds of fruit of importance except banana, avocado, and pineapple. Of the common fruits perhaps the peach, mango and guava were the worst attacked, it being next to impossible to obtain a fruit of these free from maggots.

The following parasites have been introduced:

Opius humilis Silv. from Africa in 1913.
Diachasma tryoni Cam. from Australia in 1913.
Diachasma fullawayi Silv. from Africa in 1914.
Tetrastichus giffardianus Silv. from Africa in 1914.
Dirhinus giffardii Silv. from Africa in 1913.

Records that have been kept of the work of these parasites during the past few years show that on the average about 55% of the fruitfly maggots are destroyed by the parasites. In coffee cherries practically all maggots are parasitized; in the case of mangoes, the parasites do not reach many of the maggots in the fruits, yet the fact that many mangoes escape being infested indicates a considerable reduction of the fruitfly. The guava serves also as an index, for, whereas nearly all guavas on the bushes occurring wild in the valleys and hills were infested by fruitfly, at the present time a good proportion of them escape becoming infested.

Melonfly, *Chaetodacus cucurbitae* (Coq.):

This pest gained access to Hawaii about 1895, and soon put a stop to the successful growing of melons. It is said that before that time fine watermelons were grown in great abundance, and also canteloupes, but after the arrival of the melonfly from the Orient these were grown with great difficulty and almost disappeared from the markets. All cucurbitaceous fruits became badly infested and tomatoes as well. The parasite *Opius fletcheri* Silv. was introduced from India in 1916. It has done good work against the melonfly in the gardens, as shown by the abundance of watermelons and some canteloupes the past few years. The watermelons are on the markets, too, for a period of several months each summer. Another conspicuous indication that the melonfly is pretty well controlled is that perfect cucumbers are obtainable in abundance the year round in Honolulu, whereas before the introduction of the parasite it was difficult to get good ones, they being mostly ill-shaped from having been infested by the melonfly maggots, yet survived sufficiently so that they were for sale by the vegetable pedlars. Tomatoes, too, are not nearly so badly infested any more.

11. Mesquite or Algaroba Bruchids:

Several species of bruchids have become established in Hawaii of recent years. Among them the following four feed in the algaroba pods: *Bruchus prosopis* Lec. has been known for over 20 years; *Pachymerus gonagra* (Fab.) first known in 1908; *Bruchus sallaei* Sharp in 1918; *Bruchus amicus* Horn in 1923. These algaroba pods grow in quantity and are much used as stock food. With these 4 bruchids infesting them,

their value was greatly diminished, especially if stored for any length of time. The following parasites have been introduced from Texas:

Egg-parasite: *Uscana semifumipennis* Gir., 1910.

Larval parasites: *Heterospilus prosopidis* Vier. 1910.
Lariophagus texanus Cwfd. 1921.
Urosigalphus bruchi Cwfd. 1921.
Glyptocolastes bruchivorus Cwfd. 1921.
Horismenus sp. 1921.

By the combined work of all these parasites the above mentioned bruchids are now controlled to the extent that the algaroba pods are mostly free from serious injury and their value as stock food scarcely deteriorated. Probably the egg-parasite is the most effective of these parasites.

12. Scale Insects:

There are a large number of the cosmopolitan scales, which attack many kinds of trees and shrubs in orchards, gardens and lawns in Hawaii. Numerous parasites and several lady-beetles have been introduced, intentionally or otherwise, and exercise a certain amount of control, though usually not complete control. However, these scales are usually so well controlled biologically that little effort is made to control them by insecticides. Time does not allow for taking up these individually or in detail.

As a whole the insect pests in Hawaii are pretty satisfactorily controlled by the biological methods. However, there are some not yet sufficiently controlled, and thus there remains for the entomologists the problems of searching and securing more of the natural enemies for introduction. It is likely, too, that in some cases success will not be thus attained. For example: the hornfly pest on cattle seems to be a most difficult problem to solve in this way. Several attempts have been made to find and introduce parasites or predators to combat this pest, but so far no progress in natural control has been attained.

On the Relations between the Color of Silkworms and the Environment.

Dr. Kanji Watanabe,
Imperial Japanese Sericultural Experiment Station, Tokyo, Nippon.

I. On the Tint of the Skin of Silkworms just hatched out from Eggs.

1. The temperature of incubation of eggs affects the tint of the skin of silkworms just hatched out.
2. When eggs are incubated at high temperatures, the worms become reddish in color, while at low temperature incubation they become darkish.
3. Such influences of temperatures are exerted during the course of about three days before hatching, and the changes produced under these circumstances are not inherited by the next generation.

II. On the Seasonal Changes of Color of Hibernant Silkworm Eggs.

1. The color of hibernant eggs of silkworms varies with the season of the year, i. e., in the summer it is of a deep color, but in the winter of a very light color, and it resumes a deep tint the following spring.
2. Such changes of color are caused by the change in the arrangement of pigments in the cells which constitute the serosa. Namely, in the summer the pigments are distributed uniformly in the cells of the serosa, and in the winter they gather together on one side of each cell, and in the next spring they again spread out all over the cells.
3. The movement of the pigments in the cells is due to the environmental temperatures. That is, when the eggs are placed in temperature higher than 25° C after deposition, the pigments do not move in the least, while when they are exposed to lower temperatures, the pigments gather together on one side of each cell, generally in about 30 or 40 days after being placed in such lower temperatures, and the pigments again scatter uniformly all over the cells when placed in high temperature for a few days.
4. Thus we can safely conclude that the seasonal change in the color of eggs is due to the environmental temperature.

III. On the Color of Silkworm Cocoons.

1. The temperature for rearing silkworms affects the tint of the cocoons.
2. The worms of the Japanese yellow cocoon breed, when reared at high

temperature, produce cocoons of deep yellow, while at low temperature they produce cocoons of a lighter colour.

3. The cocoons of European flesh color breed are affected also by the rearing temperatures, but the effect is somewhat different in this case, i. e., low temperature produces a deep flesh color in the cocoons, while high temperature produces light flesh color with a strong tinge of yellow.
4. The cocoons of F-1 breed of two races, flesh colour and white, are tinged with yellowish flesh color in high rearing temperature, while in low temperature they are colored light yellow with a deep tinge of flesh.
5. Cocoons of green cocoon races, or white cocoons with a light green shade, found in many hybrids, are also influenced by the rearing temperatures. In this case the high temperature causes a somewhat deep greenish tint, and low temperature makes it lighter in color.
6. The influences of rearing temperatures upon the cocoon color above mentioned are exerted only during the last stage of worms. And the changes of cocoon color effected by such environmental conditions are not inherited by the next generation.

Factors Influencing the Activity of Shade-Tree Insects and the Utilization of these in Control Work.

William Middleton, Associate Entomologist, Forest Insect Investigations, Bureau of Entomology, U. S. Department of Agriculture, Washington, D. C.

Insect infestations of shade trees present serious and complex problems. Many of the more important insect pests of shade trees have been studied by entomologists with a view to obtaining information regarding them and their control, and useful data of two types have accumulated as a result of these investigations. One class of data consists of the complete life histories of the insects. The other is a collection of miscellaneous notes on insect behavior and the various interrelationships which exist among insects themselves and between insects and other destructive agencies and conditions. Both types of data are interesting and valuable, but it is among the second type that we find those small but extraordinarily serviceable pieces of information which reveal why many species of insects are sometimes very abundant and destructive on the one hand and sometimes readily controllable on the other. The present paper will discuss briefly this second type of data.

A superficial review of the subject shows that several broad groups of notes may be distinguished. These groups are: (1) Insects and Meteorological Conditions (rainfall, temperature, etc.), (2) Growing Conditions of the Plants and Insects (site and changes in site, stand and changes in stand, selection of trees, etc.), (3) Special Behavior of Insects (adult and larval activity — feeding, cocooning and resting habits).

I. Insects and Meteorological Conditions.

For many years weather has been recognized as an important factor in tree growth and also in the distribution of insects. Entomologists have been adding steadily to our knowledge of the importance of weather in relation to insects. We are realizing that weather is intimately connected, not only with the occurrence or distribution of a species, but also with its abundance, its periodicity, and its potentialities for destruction.

One of the most conspicuous of meteorological phenomena is rainfall, and this is of decided and direct importance to plants. It is also important to many shade tree insects, but it is frequently indirect in its effect.

The behavior of certain bark beetles shows a very close interrelation with rainfall. Felt (1914) and Blackman (1924) showed a positive connection to exist between deficiency in rainfall and infestation by the hickory bark beetle (*Eccoptogaster quadrispinosus* Say). The effect on the insect appears to be indirect, or through the influence of rainfall on

the trees. Deficient rainfall for several years not only affects adversely the vitality of the trees, but, what is more significant, seems to bring about conditions in them that are extremely favorable and attractive to the beetles. This effect is reversible however, as excess of moisture produces an increase of the water in the plant tissues and this tends decidedly to check the infestation. In fact, the attack is likely to fail if this condition is present from the start. Craighead (1925) pointed out a similar relationship between deficiency in rainfall and the abundance in destructive numbers of the southern pine beetle *(Dendroctonus frontalis* Zimm.). He found that heavy precipitation while the young broods of the beetles were developing under the bark resulted in a very heavy and effective percentage of mortality.

Thus we find in the relation between insects and rainfall several points of exceptional value in the prevention or reduction of losses in shade trees by bark beetle attack. These are:

(1) The attacks of bark beetles, at least in certain species, may be anticipated when rainfall is deficient.

(2) Certain choice trees may be protected, to a considerable degree, from infestation by bark beetles through copious applications of water during dry periods.

(3) Incipient infestations of bark beetles may be drowned out by copious applications of water to the root systems of the trees.

(4) Bark beetle abundance increases during dry periods. They become either more virulent or, because of their greater numbers, they are able to attack vigorous trees. This places a special value on the anticipation and early control of outbreaks and shows the desirability and need of preventive measures.

With the pine bark beetles, temperature is also important. During the active period of the beetles (an activity largely or possibly entirely controlled by temperature), pine timber cutting operations, pine lumber, and even the turpentine in paint, show a certain attracting or concentrating influence. The beetles tend to be more injurious in the neighborhood of such work and material. This fact has led to the recommendation of cutting and burning the infested trees during the winter in the eastern part of the United States and especially in the case of ornamental and park pines.

Temperature (probably in combination with humidity) sometimes plays a beneficial role instead of an injurious one. Periods of continuous high temperature have been found to be fatal to certain insects. During the summer of 1918, in Virginia near Washington, D. C., there was a wave of extremely hot weather of approximately a week's duration. During this hot wave a maximum of 106° F was reached, while the minimum was 68° F. A large number of defoliating larvae, especially sawfly larvae, died during this hot period. One species of sawfly *(Cladius isomerus* Nort.), in which I was particularly interested at the time, remained scarce for the remainder of the year, though this insect normally undergoes six generations in the locality under consideration, which should have been ample for its recovery in abundance.

The disappearance of plant lice during hot dry weather has often been noted. This summer disappearance of shade tree aphids may not be

a direct controlling effect; indeed, it may not even be an indirect control effect. The disappearance of aphids from shade trees in hot weather may be due to a perfectly normal change or alternation of host plant, the time for which is determined by meteorological conditions. Alternation of hosts is known to occur commonly among certain species of aphids and the phenomenon undoubtedly occurs among many species for which it is not yet recorded. As examples of alternation of hosts among aphids infesting shade trees may be mentioned the maple-alder blight aphid, which leaves maple for alder in the early summer, and the elm leaf-curling and the elm leaf rosette forming aphids *(Eriosoma americanum* Haus., *E. lanigerum* Riley, and other species of the genus *Eriosoma)* which habitually migrate from elm to apple, Amelanchier, Crataegus, Ribes, and possibly other plants. Such a summer migration could easily appear to be the controlling effect of hot weather on aphids. Again, dry, warm weather could very well favor the parasites and other natural enemies of aphids, and any control effect, while possibly primarily due to the weather, is indirect, through the improvement of conditions for such parasites.

During the past year quite another meteorological effect was found complicating an insect condition. Boxwood in the Middle Atlantic States has been subject to severe annual defoliation effects produced by a dipterous insect, the boxwood leaf miner *(Monarthropalpus buxi* Lab.). In the southern part of this area a disease *(Macrophoma* sp.), which is usually considered saprophytic by pathologists, shows pronounced parasitic tendencies on bushes weakened by the miner. As a part of the treatment used in combating the leaf miner, and with the hope of preventing the development of the disease to serious proportions, fertilization and watering of the plants has been resorted to. The past winter was exceptionally mild in the region under discussion, but was marked by several short but sudden drops in temperature to the neighborhood of 20^0 F. These periods of severe cold caused considerable loss of boxwoods that had been fertilized and watered for this purpose. The stimulation thus given delayed or prevented normal dormancy from developing, and the bark of the twigs and of the trunks and large limbs in many instances split longitudinally and peeled.

The character of the weather in fall, winter or spring is also regarded as an item of great importance in determining the entomological problems of the year. Periodicity in abundance and the sudden disappearance or tremendous reduction in numbers of a species often depend upon factors other than parasitism or disease. Certain relationships affecting their abundance exist between insects — some years one group of species will be abundant, at other times different groups are dominant. The overwintering period usually is a critical stage in the life of an insect and the response to temperature is so involuntary on the part of insects that unusual seasons and sudden changes in temperature with alternate freezing and thawing must often play havoc with insect populations. The indications are that discoveries extremely useful in the prediction of epidemics, and probably in the control of injurious species, will be made in this field before many years have passed.

II. Growing Conditions of Plants and Insects.

Insect attacks on trees are fewer and less serious when the trees are growing under optimum conditions.

Swaine, Craighead and Bailey (1924), and Minott and Guild (1925) have clearly shown the effects of defoliation on both coniferous and broad leaved trees.

That the effects of defoliation are conducive to borer attack is also well known. Burgess (1915) reports that many oaks defoliated by the gipsy-moth caterpillars, trees which might otherwise recover, are killed by the two-lined chestnut and oak borer.

Fire is also a forerunner of insect attack. There are several ways in which fires may lead to tree injury by insects. The bark may be scorched, the leaves may be burned and the roots may be damaged. These are direct injuries which are frequently followed by borer attack. There is also an indirect fire injury due to soil changes that result from the burning of the normal park or forest cover. It is a common practice, at least in this country, to clear land of grass and leaves in the late fall, winter and early spring by fire. This is especially true about suburban communities. The relation of this type of fire to insects has not been investigated, but such fires destroy many defoliating and other insects in their overwintering quarters. On the other hand, they also deprive the soil of certain desirable materials.

The effects of an unfavorable vegetative environment and its connection with insect injuries may be illustrated in various ways. For some years the elm borer *(Saperda tridentata* Oliv.) has been growing in importance as an elm insect in the United States. Reports of injury have reached us from many places east of the Rocky Mountains. This injury has led to a consideration of the problem, and at one time comprehensive observations were made. In the course of these studies several facts stood out prominently. One of these observations was that elms were not thriving in some places, even in the absence of this borer. Another was that the borer did not affect vigorous, unwounded elm trees. The whole picture presented by the studies led to the conclusion that elms planted on high, dry ground, elms in cities, surrounded by concrete or other materials impervious to water, and elms suffering from severe root and trunk injuries, were especially subject to attack by the elm borer. On the other hand those trees not so situated or injured, and those trees not defoliated, were growing more vigorously and were not subject to injury by this insect.

Sometimes the place selected for tree planting appears suitable, but contains some concealed defect. This was the case with an avenue of tulip poplars *(Liriodendron tulipifera)* that came under observation. These trees had been planted along a private drive in a valley and, to all appearances, under favorable conditions. The rate of growth for the various trees was extremely irregular. Some grew rapidly, but others were sparsely foliaged and markedly slower in growth. Insects were not unusually abundant, but scale insects, aphids, ants, and a lepidopterous bark borer were present. From the owner it was learned that the borer had

attacked the unthrifty trees severely. Some of these weakened, and infested trees had died in the past and had been replaced. A study of the insect conditions alone gave no decisive and helpful information. A careful examination of the growing conditions revealed, however, that in places the subterranean rock closely approached the surface of the soil. This was the case where the trees had died and where the poorest trees now stood. The shallow soil curtailed normal root expansion and in hot dry weather must have caused considerable root injury through water shortage or too high soil temperature. The trees which had died probably were killed as a result of a complication of conditions rather than by one simple cause.

In many instances, severe borer injury follows a sudden and extensive change in the environment of trees. Trees, like animals, adapt themselves to, and grow old and cranky in, a certain environment. They thus lose considerable of their plasticity or power of adaptation. When this is the case and a change of environment comes, the vigor of the tree suffers. Often insects kill these weakened trees. In some cases the trees are actually dying as a result of such changes and merely offer ready breeding material for the insects. The association of insect attack with radical changes in growing conditions, however, is important and direct. Several examples will be used to illustrate this.

Real-estate development companies often find themselves confronted by an unexpected problem. They have obtained a wooded tract of land and have proceeded to subdivide it into building lots and to remove most of the trees. The trees permitted to remain are selected, desirable individuals that enhance the value of the property. But these trees begin to be attacked by borers and die. This is a very common occurrence. Several years ago a similar condition was found on a military reservation. Here a small wooded area had been cleared for a parade ground, leaving a fringe or margin of trees around the field. The trees in this border were attacked by borers and were dying. The cause seemed clear. The trees had adjusted themselves to a set of conditions in which the ground was shaded, leaf-covered and moist. This had suddenly been changed. The sun shining down on the now bare ground had dried and baked it. Water difficulties developed, or the roots suffered from the change in soil temperature or through the removal of near-by trees, and the remaining trees rapidly weakened and soon became infested with borers.

Another example of this interrelation between borer attack and changes in the growing conditions of trees is seen frequently where the soil is filled in around trees in grading. The changing of contours in landscaping and building is frequently necessary or desirable, but sometimes this works great hardships upon the trees. Not infrequently the two-lined chestnut and oak borer (*Agrilus bilineatus* W e b.) has been found attacking and killing oak trees that were thus handicapped.

Here should also be considered the insect injuries following transplanting. There are two things to be considered. One is that many trees probably would survive transplanting but for the fact that during their period of readjustment they are attacked and killed by insects. In this

case borers are again the chief offenders. Pine, spruce, dogwood, maple and other trees are continually being purchased and transplanted. Even when the greatest care is exercised in this operation, loss of vigor follows. The tree thus becomes an attractive and easily killed prey for some boring insect. Certain species of *Ips* and other trunk-infesting engraver beetles, some of the twig bark beetles, and even round-headed and flat-headed borers, are known to attack and kill transplanted conifers. A flat-headed bark and wood borer attacks dogwood, and a flat-headed borer and one of the clearwinged moths frequently infest maple under such circumstances.

The second consideration in transplanting involves the conditions under which it is proposed to grow the tree in its new location. Is it, for example, a rich, moist, shady bottom land, a high, dry, bald hill top, or a steep bank? Where the tree came from and where it is to go and its own natural requirements are intimately related to success in keeping it free from attack by borers and in a state of vigor likely to sustain it under insect attacks. Here, too, we find the problems connected with the abundance of a tree species throughout a locality which favors a multiplication of its enemies, and with the purity or character of mixture of a park or ornamental planting. Even under shade tree and park conditions these considerations are important from an entomological standpoint.

III. Special Behavior of Insects.

There are many instincts or habits of insects which are peculiar to the species and which offer decided possibilities for control purposes. It is of the utmost importance that such characteristics be recognized and utilized by entomologists. In the work against a considerable number of species we find excellent examples of the use of such characteristics in the control of the insects possessing them.

Some insects are by nature sun-loving in the adult stage. The metallic wood-borers (Buprestids), for instance, as a group appear to be of this character. *Agrilus,* the genus to which the two-lined chestnut and oak borer and the bronze birch borer belong, seems to be especially so. The locust borer *(Cyllene robiniae* Forst.) is known to be sun-loving, and recommendations for the prevention of injury by it take this liking into consideration. Craighead (1919) finds that dense stands of locust in which the weeds and underbrush are allowed to remain, are the least subject to injury by this borer. In the few instances, during the last few years, in which I have seen injury by the bronze birch borer in the field, I have been impressed by the existence of an apparent connection between injury and the open growth and dry situation of the trees. This relationship has been observed, also, by Dr. S. A. Graham of the Department of Forestry and Conservation, University of Michigan, and probably by others, so it seems worthy of attention and further study. This association is the more significant when we consider that the two-lined chestnut and oak borer *(Agrilus bilineatus* Web.) is more of a shade-tree and park problem than a forest problem and that the insect appears to be a more

injurious pest when it follows clearing out and grading operations or defoliation.

Information regarding the cocooning, pupation and overwintering behavior of insects is also useful. For instance, the female bagworm lays her eggs within the bag or sack in the fall and the eggs remain there over winter. This forms the basis of the recommendation for picking and destroying the bags before the eggs hatch. The occurrence of overwintering egg masses of the gipsy moth and the white-marked tussock moth is used as the basis for one method of control of these species. Leaf miners often use their mines within the leaves as a place for hibernation, thus avoiding the necessity of deserting the leaves and finding or constructing some new protection. The white-blotch oak-leaf miner (*Cameraria hamadryella* Clem.) and other species have this behavior. The sawfly leaf miner of birch (*Phlebatrophia mathesoni* MacG.), at present so abundant in New England, spins its cocoon within the mined leaf. Even some borers such as the twig-pruners (*Elaphidion* spp.) and the twig-girdlers (*Oncideres* spp.) have a hibernation habit of which advantage is taken in combating them.

Insect behavior is usually based on some very important requirement of the species. For instance, the activity of a species for dissemination is an important kind of behavior which is based on the need for an environment where competition for food will be less severe and where optimum conditions prevail and the chances for survival will be greatest. Insects have met the need for dispersion in a variety of ways. We usually find that adult insects are equipped with wings and legs, both of which are efficient mechanisms of locomotion, and that they have a decided tendency to migrate at times. Among some species, such as the white-marked tussock moth, the gipsy moth, the cankerworms, the bagworm and others, the female adult either is wingless, a poor flier, or is otherwise handicapped as regards locomotion. To compensate for this lack of adult motility and to insure distribution, a wanderlust manifests itself in the larval stage, usually after the feeding period is finished. Advantage has been taken of this peculiarity of certain insects in efforts at controlling them by means of treebanding and barrier methods.

Under the discussion of Insects and Meteorological Conditions the attraction for certain borers shown by weakened trees was discussed. This field of insect attraction is one of unquestioned importance, hence baiting with extractives of the host plants is being tried for a number of insects of economic importance, including the Japanese beetle. The attractive qualities of pine lumber and turpentine for the pine bark beetles during the summer time was mentioned and their use in controlling these insects commented on. Van Dyke (1926) has given the following interesting account of attraction that illustrates the tremendous possibilities of this phase of insect behavior in connection with both shade tree and forest work. A 750,000 barrel tank of oil burned at Coalinga, California, in August, whereupon the buprestid beetle (*Melanophila consputa* Lec.) appeared immediately in great numbers, although no conifers were located nearer than 50 miles from the site of the conflagration. According to oil engineers, such flights are of rather common occurrence.

Literature.

1. Felt, E. P. — Notes on Forest Insects; in Journ. Econ. Ent., Vol. 7, No. 5, 1914.
2. Burgess, A. F. — Report on the Gipsy Moth Work in New England; U. S. Dept. of Agric. Bul. 204, 1915.
3. Craighead, F. C. — Protection from the Locust Borer; ibid. Bul. 787. 1919.
4. Blackman, M. W. — The Effect of Deficiency and Excess in Rainfall upon the Hickory Bark Beetle; in Journ. Econ. Ent., Vol. 17, No. 4, 1924.
5. Swaine, J. M., Craighead, F. C. and Bailey, I. W. — Studies on the Spruce Budworm; Dept. of Agric. Dom. Canada Bul. 37, New Series, 1924.
6. Minott, C. W. and Guild, I. T. — Some Results of the Defoliation of Trees; in Journ. Econ. Ent., Vol. 18, No. 2, 1925.
7. Craighead, F. C. — Bark-beetle Epidemics and Rainfall Deficiency; ibid. No. 4, 1925.
8. Van Dyke, E. C. — Note in Pan-Pacific Ent., Vol. 3, No. 1, 1926.

Codling Moth Control and Removal of Spray Residue from Fruit in South Africa.

F. W. Pettey, Ph. D., Acting Senior Entomologist,
Department of Agriculture, South Africa.

In South Africa there are approximately 12,000 acres of pear and 24,000 acres of apple trees. The pear orchards vary in size from 30 to 300 acres, the average size being probably 40 acres. Several apple orchards are much larger. Many pear orchards are now in full bearing and are 30 or more years old. Last season, about 700,000 boxes of pears were exported to England. In 1926 about 26,000 boxes of apples were exported. Much of the fruit produced must be shipped out of the country. The population consists of only about 1,600,000 whites and consequently local markets can absorb only a comparatively small amount of fruit. The blacks, which number about 6,000,000, cannot afford to buy fruit. It is therefore of importance to produce fruit of the best quality. Pears and apples of "selected" ("fancy") grade must be free of stings and infestations. Fruit inspectors make no distinction between stings and infestations as far as export fruit is concerned.

Codling moth is the most serious pest with which the pear and apple grower in South Africa has to contend. The infestation in most apple orchards is not so heavy as in pears, because the former are located at high elevations, 2 to 6,000 feet above sea level, where the nights are cold and where probably there are only two generations of the insect. Therefore most of the investigations in the control of this pest have been confined to pears.

Codling moth is a serious pest in South African pear orchards for several reasons: (1) The orchards are located in low lying inland valleys practically free from frost in the winter and sufficiently distant from the coast to result in the nights being warm, thereby allowing the moths to lay their maximum number of eggs. (2) The summers are dry and hot. (3) Over 75% of the pears are late maturing varieties. There are three broods of codling moth larvae, and these late pears are exposed to infestation from the three broods. Moths fly continually in a commercial orchard from the time the trees are in blossom until the fruit is harvested. However, there is a time of maximum emergence of the different broods of moths, but it varies from season to season and in different valleys. Eggs begin hatching in the orchard before all the petals of the late blossoming varieties have dropped. (4) The orchards are large and of mixed varieties, some maturing early, some in midseason, and some late. This probably results in concentration on the later maturing varieties of the moths which develop from

larvae that escaped the sprays put on the early varieties of fruit. (5) In South Africa continual South-east winds, prevalent during the period of setting of the fruit, adds to the sprayers' difficulties.

Codling moth is particularly serious for the South African fruit grower, because satisfactory control demands thorough spraying. Thoroughness is difficult to attain where the sprayers are native blacks. They are not only ignorant of the habits of the insect (95% of them can neither read nor write), but also they have no financial interest in the crop which they are made to spray.

Spraying machinery, oil and gasoline are twice as expensive in South Africa as in America, and labor is four times cheaper in South Africa than in America. Taking into consideration all these facts, control measures supplementary to spraying, such as trapping larvae in bands, and picking off and proper disposal of wormy fruits, are relatively more important for the South African fruit grower than for the American fruit grower.

The division of Entomology officially advises for orchards in low lying valleys 5 to 7 applications of lead arsenate at the rate of 1¼ lbs. in 40 imperial gallons of water, the cover sprays to be applied at intervals of 2 to 3 weeks after the application of the calyx sprays. Fruit growers are encouraged to make use of "hootch" traps better to time their sprays, but this practice has not been adopted generally. Sufficient attention to control measures supplementary to spraying are urged to allow the omission of the last two of the five cover sprays. Apple orchards at high elevations require no more than 3 cover sprays and 2 calyx sprays. However, fruit growers who rely on natives to spray get better results by spraying at short intervals. To facilitate thorough spraying in windy conditions growers are advised to have one man spray with a rod from the top of the tank, and another spray with a gun from the ground.

Personal experience, careful observations and experimental spraying under various conditions in different parts of the country convinces me that this programme, if thoroughly and properly carried out, will effectively control codling in all commercial orchards in South Africa. No strain unusually resistant to arsenate has developed in South Africa. There is ample evidence to prove that failure to control, when it occurs, is due to neglect in keeping spray outfits in good working condition, and to failure thoroughly to drench all parts of foliage and fruit. Extensive tests were made in several late maturing pear varieties of two orchards last year to determine whether doubling the normal strength of lead arsenate was advisable*). A full spray programme of normal strength lead arsenate resulted in an infestation of from ½ to 5% in the three varieties tested. When a similar programme of double strength of lead arsenate was applied the infestation in these three varieties was from ½ to 3.2%. Doubling the strength of the sprays resulted in somewhat better control, but a full spray programme of normal strength sprays was so effective that the expense insolved in doubling the amount of lead arsenate was not justified.

For two consecutive years thorough tests of calcium caseinate spreader in full spray programmes of double and normal strength of lead arsenate on several varieties of pears have shown that the spreader did not improve

*) Normal strength: 1¼ lbs. of standard powder in 40 imperial gallons of water.

the efficiency of the lead arsenate in the control of the pest. The spreader was used at a dilution recommended by the manufacturer.

The entomologist, or the intelligent experienced sprayer, can obtain good results with a spray programme of normal strength during seasons of normal crops, with the aid of bands on the tree trunks for trapping of larvae, but a large proportion of commercial fruit growers cannot do so for reasons already mentioned. During seasons of good crops the average infestation in commercial orchards is 10 to 15%, and in seasons of poor crops the average infestation is from 20 to 50% in orchards which have received a normal full spray programme.

Lead arsenate is not a perfect measure of control. This is particularly evident when the fruit crop is small and when the proportion of codling worms to fruit is comparatively large. Therefore, the grower is urged to give sufficient attention to control measures supplementary to spraying during seasons of good crops to reduce the number of larvae that might escape in the orchard and pack house to the lowest possible minimum.

Since trapping of larvae in bands placed on trees in the orchard is not sufficient to accomplish this, a trap was devised to capture all larvae crawling from infested pears brought to or near the pack house.

It is the practice of South African pear growers to dry their mature infested fruit. In the past they have usually placed their wormy fruit in piles on the ground or floor in or near the pack houses until the pears were sufficiently ripe to be cut up for drying. In the interim 95% or more of the codling larvae have escaped from such fruit to hibernate near the orchards and develop into moths, which are mainly responsible for the infestation in the next season's crop of fruit. The South African pack house is of such construction that it cannot be closed to the exit of moths.

The larva trap is a simple and economical structure which may be placed along the inner surface of a low walled out-of-doors enclosure or room surrounding the accumulated infested fruit. It is fully described in *Bulletin 9*, 1926 of the Union of South Africa *Dept. of Agriculture*.

Fruit growers are not only urged to make use of this trap for storage of mature infested fruit harvested, but also for proper disposal of immature infested fruit and windfalls. It costs the fruit grower no more to have 5 natives do nothing for two months but continually seek for and pick off infested fruits on the trees than it costs to apply two lead arsenate sprays to 10 acres of large trees. The regular picking off through the fruit season of as much wormy fruit as is practical and the proper disposal of such fruit in the enclosure containing the larva trap to prevent escape of worms makes it possible after the first year of such practice to reduce the number of sprays on late maturing varieties from 7 to 4 or 5, and from 5 sprays to 3 on early maturing varieties, and it is then possible very successfully to control the pest even during seasons of poor crops.

This reduction of the number of sprays to 4 or 5, with an interval of 8 to 9 weeks between the date of the last spray and the date of harvesting, will reduce the amount of spray residue on fruit of the largest export size to less than $^{1}/_{100}$ of a grain of arsenious oxide per pound, but the smallest export size fruit would contain somewhat more. Thus treatment for removal of spray residue could not be avoided entirely.

There is little opportunity in this short paper to discuss or explain what investigational work has been done in South Africa in connection with the spray residue question. Several substitutes for lead arsenate sprays were thoroughly tested in 1926 *). These included lead chromate, hootch bait traps (two placed in each tree) and sprinkling the foliage of the trees lightly once every 2 weeks with sweetened lead arsenate as for the control of the Mediterranean fruit fly in stone fruits. They were found to be much less efficient than lead arsenate spraying. One application of sodium fluosilicate spray on Kieffer pears burned the foliage and fruit so badly that the test was abandoned.

No spray programme of "summer oil" alone was tested. It was not considered practical because of the expense involved in repeated sprays at necessary short intervals. One calyx of lead arsenate and 3 cover sprays of lead arsenate at normal strength combined with a 2½% "summer oil" emulsion was found completely to control the first brood of codling larvae in Bosc pears, while a similar programme of lead arsenate alone resulted in an infestation by the first brood of more than 3%. The crop was small and the proportion of hatching larvae to fruit in the orchard was comparatively large. The oil used interfered somewhat with the removal of spray residue by the HCl acid treatment. It caused no evident injury to foliage or fruit.

Investigations of methods for the removal of spray residue from fruit have occupied the serious attention of the Department **).

Dry wiping, dry brushing and washing in water arsenate-sprayed pears were thoroughly tested. Results have shown that these methods would remove only 30 to 50% of the spray residue. None of these methods would reduce the amount of arsenate on pears to below $^1/_{100}$ of a grain per pound, since most of the fruit harvested in the country contained 3 to 6 times that amount. Submerging the fruit for one or more minutes in dilute solutions of HCl, the method originated by Hartman and Robinson, was tested on Kieffer and Bosc pear in 1927 and was found to be succesful.

At the beginning of the 1928 fruit season, after reports of details of acid treatment had been received from the U. S. Bureau of Entomology, the South African Dept. of Agriculture adopted regulations requiring that all fruit offered for export to England and elsewhere must have no visible traces of arsenate. No fruit that had received one or more sprays of lead arsenate was allowed to be exported unless it had previously been dipped or washed in a solution of HCl. These regulations were strictly enforced, and fruit inspectors were placed in different districts to assist growers in carrying out the regulations.

The regulations were not drastic, considering the conditions. Machinery that had been devised for dry treatment of the fruit was considered to be either unsatisfactory or not sufficiently cheap to be practical. Hand washing, brushing and wiping by natives was out of the question.

---

*) For details of these and other experiments see Union of S. Africa Dept. of Agriculture, Entomological note 37, 1927, and Science Bul. 64, 1928.

**) Farming in South Africa, Vol. III, June, 1928, and Science Bul. 64, 1928.

Most orchards are of mixed varieties, and the late maturing were more heavily sprayed than the others. It was impractical to determine which of these in each orchard would and which would not require treatment for removal of spray residue.

The general method adopted by most growers was as follows: After the boxes of pears were brought from the orchard, they were almost immediately placed 1 to 3 minutes in a long trough containing either $^1/_2$ or 1% solution of actual hydrochloric acid, and after being drained about a half minute on a sloping shelf between the two troughs, they were placed in a trough of clear water for 2 minutes, soon after which the fruit was graded, wrapped and packed.

During the past season extensive tests of the HCl acid treatment were made with 12 varieties of pears and eight varieties of apples to determine the limitations of the treatment and to improve it if possible. Some pears had been heavily sprayed, and others had been sprayed with a normal programme.*) All fruits tested were submerged in the acid solution for a definite short period, then drained a half minute and then submerged in water for two minutes.

Some of the more important results follow**).

Some pear varieties were found to be more resistant to acid injury than others. Mature Duchesse, Beurre Clairgeau, Forelle, and Winter Nelis pears tolerated 5 minutes in 1% actual HCl at a temperature of 74 F, but mature Bartletts, Comice, Louise Bonne, Buerre Hardy, Kieffer and Clapps Favorite tolerated no more than 2 minutes in 1% HCl at this temperature and 1 minute for draining.

Bartletts and Louise Bonne pears not quite fully mature tolerated no more than 1 minute in 1% HCl at this temperature plus one minute for draining.

Pears were found to be more susceptible to injury than apples. Apples tolerated 6 minutes in 1% or 11 minutes in ½% HCl including the one minute required for draining.

Some varieties of pears were found to tolerate more acid in the rinsing water than others. Some Bartlett, Comice, Louise Bonne, and Glou Morceau pears would not endure one sixtieth per cent in the rinsing water, but Duchess and Beurre Hardy varieties tolerated $^1/_{30}$ % and Winter Nelis $^1/_{20}$th% without any injury resulting after they had dried. Apples were found to tolerate more acid in the rinsing water than pears.

It was found that two types of injury to pears might result from treatment in hydrochloric acid. The one consisted of the collapsing and blackening of the fruit lenticels and the other consisted of burning of the skin area, which turned brown***). The former resulted from too long submergence of the fruit in the acid solution, or from the accumulation of too much acid in the rinsing water. When such lenticel injury occurred uniformly over a considerable area, the damage was due to submergence of the fruit for too long a period in the acid solution. When such injury was

*) 1¼ lbs. lead arsenate powder in 40 imperial gallons of water.

**) Fuller details obtainable in Farming in South Africa, Vol. III, No. 27, June 1928.

***) See Farming in South Africa, Vol. III, July, 1928.

localized in one or several scattered small areas, it was caused by the accumulation of too much acid in the rinsing water. Localized lenticel damage resulted when the fruit, which had been rinsed in the acid contaminated water, was drying; the water evaporated first from the drops of liquid on the fruit, leaving smaller drops of the more concentrated acid solution which invaded the lenticels and caused injury.

Immature pears were found to be most susceptible to lenticel damage probably because the cork layer which protected the skin of the fruit from rapid invasion of the acid had not at this stage developed sufficiently at the base of the lenticels to prevent the penetration of the acid.

Burning of the skin occurred when pears that had been rinsed in acid contaminated rinsing water were left for some time in the boxes. The injury appeared where the fruit touched either the acid contaminated excelsior (wood wool) in the bottom of the box or where the pears touched absorbant bottom boards of the box. In such conditions the acid solution in the wood wool or absorbant boards concentrated as the evaporation of the water continued. It was found that such injury could be avoided either by removing the fruit from the boxes as soon as rinsing was completed or by drenching each box of fruit with clean water for a few seconds as soon as it was removed from the rinsing trough. Localized lenticel injury could also be avoided by the latter treatment.

The South African fruit grower finds it necessary to place straw or excelsior in the bottom of his boxes to avoid abrasion of the skin of the pears during the transportation of the fruit from the orchard to the pack house. This material retards draining of the fruit after it is removed in the boxes from the acid solution, and rather rapidly accumulates acid in the water trough. The greater the number of boxes of fruit that were dipped in acid solution and rinsed simultaneously the more rapidly acid accumulated in the rinsing water, and the more necessary it was to drench each box of fruit a few seconds with water free from acid, preferably from a short hose attached to a water pipe located near the end of the water trough, just after each box was removed from the water trough. When this was practised, as much as $^1/_{15}$ % of actual acid was tolerated by pears in the rinsing water of the trough. This procedure was found to be indispensable to avoid risk of injury to fruit when several boxes or more of fruit were trated at the same time.

Some of the South African growers had a limited supply of water. An abundant supply for rinsing the fruit was found to be very desirable. The addition of bicarbonate of soda in the rinsing water at the rate of 1 pound in 80 imperial gallons allowed the amount of water for rinsing each bushel of Bartlett pears after treatment in 1% actual acid to be reduced from 4 gallons to 1½ gallons, because of its slow effect in reducing by more than 50% the acid that accumulated in the rinsing water.

It was found that with few exceptions submergence of pears (that had received 7 normal arsenate sprays) for two minutes in 1% actual hydrochloric acid, draining one half to one minute, and rinsing in plenty of practically clean water for two minutes at ordinary tap water (pipe water) temperature, would effectively remove arsenical spray residue from mature pears without causing any injury. Apples may be submerged 4 to 5 minutes in 1% acid if necessary, to reduce the spray residue, but this long period

was found to be generally unnecessary unless the fruit had been heavily sprayed or had been stored for some time, and had accumulated wax, or unless the solution was considerably below 70° F. Submergence of pears for 2 minutes in 1% HCl was generally more effective in the removal of visible spray stains than submergence for 5 minutes in ½% acid.

Fruit growers are cautioned not to pick pears that are to be treated for removal of arsenate by acid until they are mature, particularly Bartletts (Williams) and Louise Bonne, as they will not tolerate submergence for 2 minutes in 1% HCl or even 4 minutes in ½% HCl.

Under South African conditions it is quite unnecessary to allow pears to dry, after treatment, before they are wrapped and packed. Over 100 trays of 12 varieties of pears wrapped and packed wet immediately after treatment, and placed three weeks in cold storage at 34° to 35° F were not at all affected. No damage resulted to 12 large boxes of these varieties treated in the same manner.

The 1928 fruit season closed most satisfactorily for South African pear growers. About seven hundred thousand boxes of pears were exported and all had been treated for removal of spray residue by the acid process at much less expense and labour than by the unsatisfactory and tedious method of hand wiping and brushing.

But the acid method was found not to be a perfect one. Reasonable care had to be exercised to avoid injury. To avoid risk of injury to fruit, an abundant supply of water was necessary. It cost the average fruit grower 500 to 1,000 dollars. However, no appreciable damage resulted. No injury to pears from arsenious oxide was reported even though the acid solution used in the troughs was seldom replenished. Apparently pear growers are so satisfied with it that they will hesitate to accept any other method of cleaning fruit, unless it can be proved to be considerably more economical and more fool proof.

So long as the Regulations with reference to fruit for export require treatment for removal of spray residue when even one lead arsenate spray is applied, fruit growers will not be interested in anything but a complete substitute for a arsenical spray at least equally as efficient as the arsenate.

It may be of interest to you to know that in South Africa there is a chalcid codling egg parasite of a different genus and species than *T. minutum* *). It is an egg parasite of the Citrus false codling moth, *Argyroploce leucotreta,* of *Sitrotroga cerealella* and of a Lycaenid butterfly, and it probably breeds in the eggs of several cotton boll worms. Investigations contemplated may show that this parasite, *Trichogrammatoidea lutea* Girault, will prove to be a valuable supplement to *T. minutum* in artificial breeding for natural control of the codling moth.

---

*) Description and life history of South African egg parasite; in South African Journal of Science, Vol. XVI, Oct.—Dec., 1919, by F. W. Pettey.

The Codling Moth Problem in North America.

B. A. Porter, Bureau of Entomology, U. S. Dept. of Agriculture, Washington, D. C.

The occurrence of the codling moth in practically all apple-growing regions of the world, and its outstanding importance in most of them, constitute ample reason for a discussion of the problem at an international gathering of this nature. Preliminary to the detailed discussions which are to follow, a brief summary of the past history and the present status of the codling moth problem in America seems worth while. This has been prepared primarily for the information of our friends from other countries, and of necessity includes material which is already familiar to many in this gathering.

A discussion of the codling moth problem may well start with a brief discussion of the apple industry, which is the one chiefly affected by this species. Without citing an extensive array of statistics, the magnitude of the apple industry may be indicated in the fact that the commercial crop ranges from 25 million to 35 million barrels of apples annually, and has a monetary value of some $ 150,000,000 every year. In addition to this, there is a nearly equivalent volume which is consumed locally.

Owing to the wide adaptability of the apple, it may be grown successfully under extremely diverse climatic conditions. In the more southern apple regions the growing season is long and characterized by almost tropical heat; in the northern sections the seasons are short and cool. By means of irrigation, apples are produced successfully under virtually desert conditions, although they normally grow in regions of moderate rainfall. Commercial apple orchards may be found a few feet above sea level, and up to elevations of 5,000 feet or more. Such diverse climatic conditions have made the codling moth problem an extremely variable one.

In the early days, in fact until seventy-five years ago, apples were produced chiefly in small home orchards. Except where climatic conditions absolutely prevented it, nearly every farm had an orchard of an acre or more with a mixture of varieties giving a succession of fruit for home consumption from July until winter. Any surplus was marketed in near-by towns and cities, which were sometimes oversupplied with fruit in the fall, and, except for fruit stored in cellars, were usually destitute of apples in late winter and spring. A few sections were gradually developing as commercial orchard centers, but the plantings were usually small compared with some of the orchards of today.

This gradual process of specialization was remarkably accelerated by the coming of refrigerator cars and cold storage ware-houses, which permitted the development of extensive apple production in sections thou-

sands of miles from the chief consuming centers. The farm orchard is gradually disappearing, and the industry is being concentrated in a comparatively few sections which are on the whole particularly favorable to apple production. As a result, the codling moth finds itself in large, often practically continuous, areas of its favored food, with crops present every year, at least in sufficient volume to carry the species from season to season in large numbers.

To add to this advantage, the codling moth has found itself in many cases under climatic conditions which are extremely favorable to it. This is particularly true of the hot, arid sections of the West, where the species has become extremely prolific and abundant, and consequently very difficult to control. Under the conditions prevailing in some of the sections most seriously affected, control methods have hardly kept pace with the increasing acuteness of the problem, in spite of the best efforts of the entomologists who have been concerned with its solution.

A contrast to this extreme condition is that which may be found in the cooler, more humid portions of the country, such as the section in which this meeting is being held, where the codling moth, although present, and often quite injurious when control measures are neglected, may be readily controlled by a comparatively small number of spray applications.

The history of the control methods employed against the codling moth in the United States has been, in a sense, parallel to the development of the apple industry. Until fifty years ago, control was accomplished by mechanical methods, such as destroying the worms under bands, and destroying wormy fruit. It is difficult to obtain accurate comparisons between the control obtained by those methods and the control obtained today under present conditions, but according to the beliefs cherished by the older generation the apple crops produced in their childhood were just as perfect as those of today. It seems possible, however, that wormy fruit was accepted seventy-five years ago more as a matter of course than it is by the consumer of today.

From the discovery that Paris Green would control the canker worm, it was but a short step to the discovery in 1878 that it would also control the codling moth. Then followed the discovery of the value of lead arsenate — first a homemade paste of variable composition, then a commercially prepared paste, and finally the commercial powdered material which is in almost universal use today. Lead arsenate came to be looked upon as a perfect stomach poison, and during the past twenty-five years the apple industry has become dependent upon this one means of control. Practically all of the experimental work conducted during that period, until two or three years ago, was directed towards a more effective use of this material. The equipment for applying the poison has developed from the earlier hand-operated pumps and uncertain power-driven outfits to the present-day power sprayers, or stationary outfits, which have now reached the point where they will deliver spray material day after day at a faster rate than the average spray crew can properly cover the ground. Time will not permit going into greater detail regarding many of the interesting episodes which occurred during this period.

The almost complete dependence which in recent years growers have placed on lead arsenate for the control of the codling moth has had a marked influence on the biological studies which have been made of this species. For the past twenty years studies of the biology of the codling moth have been shaped almost entirely to give information which would aid in timing spray applications. The result has been a long series of detailed life-history studies, which have been conducted in almost every section where the codling moth is a problem, and on which our present spray calendars are based.

In spite of the confidence which had been placed in lead arsenate, there began to develop a few years ago in certain sections an undercurrent of dissatisfaction with spraying as a control measure. This feeling was suddenly crystallized about two years ago by a paper presented by Dr. R. H. Smith*), of the University of California. Among other important points, this paper showed very definitely that an astonishing proportion of worms could make their way into the fruit in spite of a heavy coating of lead arsenate. As pointed out by Smith in this and in other papers, lead arsenate is least effective when used to prevent side entrances during the latter part of the season. At this time many of the worms hatch from eggs laid directly on the fruit, whereas early in the season many of the worms appear to be poisoned on twigs and foliage before reaching the fruit, and a high percentage of those reaching the fruit attempt entrance through the calyx, where lead arsenate appears to have its maximum efficiency. The parts of the country which are experiencing the greatest difficulty in codling moth control are those in which there occurs a heavy hatch of late worms, and the lack of effectiveness of lead arsenate late in the season is one of the important factors involved.

Since Smith's paper, the first reports of the work of Dr. W. S. Hough,**) of the Virginia Agricultural Experiment Station, have appeared, showing that some strains of worms are much better able than others to thrive in the presence of heavy deposits of arsenate of lead. While it is not yet exactly clear to what factor the apparently resistant strains owe their ability to survive, the significance of this work is readily apparent.

In all this discussion it should be kept clearly in mind that over the greater part of the country lead arsenate is still giving very satisfactory control. It is only in certain sections where conditions are particularly favorable to the species, where heavy late broods occur, and where climatic conditions appear to render the moths unusually vigorous and prolific, not to mention the possible factor of tolerance to the poison, that serious difficulties occur. In the North-eastern part of the United States and in Eastern Canada, where cool nights occur during the greater part of the oviposition season of the spring brood of moths, where the second brood is usually of moderate proportions, and where no third

---

*) 1926. Smith, R. H. The Efficacy of Lead Arsenate in Controlling the Codling Moth; in Hilgardia, Vol. 1, No. 17, pp. 403—454, illustr.

**) 1928. Hough, W. S. Relative Resistance to Arsenical Poisoning of Two Codling Moth Strains. J. Ec. Ent. 21, p. 325—329.

brood occurs, no serious difficulty has been experienced in controlling the pest with a minimum number of spray applications.

In the meantime there have arisen the spray residue difficulties which Messrs. E. J. Newcomer, of the U. S. Bureau Entomology, and Leroy Childs, of the Oregon Agricultural Experiment Station, will discuss in detail. The outcome of these difficulties has been the development of the acid bath process of cleaning the fruit of excess residue. As will be brought out, this process has from the pressure of necessity been rapidly adopted in the Northwest, and is likely to become a permanent part of the process of preparing apples for market wherever spray residues are a factor, and possibly elsewhere.

The dissatisfaction with lead arsenate in certain sections stimulated several years ago a partial return to the older mechanical means of control, particularly banding, and caused closer attention to sanitation in the orchards most affected. It also stimulated in a few sections a search for better means of control. The sudden development of spray residue difficulties intensified and extended these efforts, and the codling moth has been given more attention in the past two years than at any other period in history.

Now that we have passed the feverish period which occurred between the first realization of the spray residue situation and the time when the success of the acid-washing method became assured, it is possible to take a calmer view of the problem, to take stock of the situation, and to attempt if possible to determine in what direction further effort may be expended to best advantage. A brief summary of the present status of investigations on the various phases of the problem and their apparent trend may be useful in this study.

The first possibility that suggested itself was that of another stomach poison to replace lead arsenate. The desirability of getting away from the poisons so dangerous to people was obvious, but the problem of finding a poison deadly to the insects, and yet safe for human beings in the quantities in which it is likely to be present on fruit, is a difficult one. From the residue standpoint, arsenic would be much less objectionable if it could be used in combination with some non-toxic base. The possibility of such a combination has been gone into very thoroughly during the last two seasons, but no arsenical has yet appeared which approaches lead arsenate in effectiveness and in safety on foliage. Among the non-arsenical stomach poisons, the fluorine compounds seem to offer the greatest promise. Though the fluorine compounds are toxic to human beings, they seem to be sufficiently less toxic than lead arsenate to warrant the hope that some of them may prove unobjectionable in the quantities in which they would occur on the fruit. The field of organic compounds has hardly been touched as yet. At present it must be freely admitted that nothing is in sight to immediately replace lead arsenate.

Contact materials for codling moth control, in striking contrast to the arsenicals, have received scant attention until very recent years. The obvious limitations of ordinary contact materials, which kill only on direct application, seem to have discouraged investigators. A successful contact material for codling moth control must possess qualities in addition to its immediate effect at the time of application. It must kill any

eggs which are laid on the sprayed surface, must persist as a contact or stomach poison against later hatching worms, or must repel the moths or larvae from the fruit. Several contact materials which are under investigation are known to possess these necessary additional qualifications in varying degress. The oil sprays and nicotine seem to come nearer to this ideal than any of the other materials. In the case of nicotine, experimental work is now being directed towards increasing its persistence on the tree, the direct opposite of the quick liberation which is desirable when nicotine is used as an ordinary contact spray. The status of the oil sprays will be discussed by Mr. Newcomer. Derris and pyrethrum may prove of value, and other contacts are in the process of development.

Every new material brought into consideration, however, brings with it new problems to be worked out, and new complications to be adjusted. For instance, one of the newer contact materials is rendered practically non-toxic to insects when lime or Bordeaux mixture is added to it. As a matter of fact, the spray materials now in use involve a series of similar problems which are well worth serious attention. The common practice of mixing lead arsenate with lime-sulphur has been definitely shown to reduce the efficiency of the lead arsenate in codling moth control, and there are indications that Bordeaux and hydrated lime have similar effects. This is only one of many problems which need careful study in the laboratory and in the field.

Another phase of the problem which needs a more complete study is that of type of coverage and its correlated problem, the use of spreaders. When one entomologist recommends the use of about as much casein spreader as of lead arsenate, and stresses his belief in the importance of a film coverage; when another entomologist recommends the use of casein spreaders, but in minimum amounts; and when a third condemns altogether the use of spreaders, and recommends a coarse, spotted type of coverage, it is very evident that we are far from an understanding of the fundamental factors which govern the action of lead arsenate on the codling moth. Closely related is the important factor of adhesiveness. In fact, the more one scrutinizes our present ideas relating to insecticide control of the codling moth, the more one becomes impressed with the need of a fuller understanding of the underlying principles of insect toxicology. It is to be hoped that in addition to the discovery of more satisfactory and less objectionable insecticides, the work under way may add to our understanding of the fundamentals.

In judging the progress in investigations of the various new insecticides, one should not be too hasty in condemning materials which cannot be put into immediate practical use, but should bear in mind that lead arsenate as known today was the culmination of thirty years of experimental work with arsenicals, and was at first considered too expensive for practical use.

The recent return to mechanical means of control, as a supplement to spraying, has already been mentioned. Much of this is merely a revival of practices already known, and chiefly within the province of the extension entomologist. Improvements are possible, however, and the experimental work now under way will undoubtedly clarify certain points which are insufficiently understood at present. For instance, the fact that

four or five distinctly different types of bands are recommended by different workers shows that the reactions of the worms in search of hibernating quarters are not yet fully understood, simple as they may seem.

The development of the chemically treated, automatic band, as recently suggested by Mr. E. H. Siegler and his associates in the U. S. Bureau of Entomology *), promises an important improvement in control by banding, eliminating the necessity for manual labor during the summer, when labor is often at a premium. This method, if successful, will also lend emphasis to the various forms of orchard sanitation, in order to give the bands their maximum efficiency.

Studies are also being made of hibernation conditions, with particular reference to the percentage of survival among worms hibernating in various situations. A more accurate knowledge of these factors is needed in working out orchard practices which may result in conditions unfavorable to the species.

Mr. Newcomer will outline in detail the work done in the Northwest with moth baits. In other sections of the country the moth baits have thus far given poor results. The field of chemotropic control will undoubtedly be further exploited in the future, particularly if reliable means are worked out for measuring quantitatively the reactions of the insect to various chemical stimuli. The olfactometers recently devised have been valuable efforts in this direction, but further work is needed before the reactions of this particular species can be accurately measured. When this technique has been mastered, the search for attractive and repellent materials will proceed more rapidly and on a sounder basis.

Interest in the possibility of biological control of the codling moth has been stimulated by the work of Mr. Stanley E. Flanders**), of the Saticoy (Calif.) Walnut Growers Association, with the egg parasite *Trichogramma minutum* Riley, in the control of the codling moth in walnuts in California, and preliminary work with the utilization of this species is under way at a number of points. *Trichogramma minutum* appears to be a species well adapted to artificial manipulation. Further study may show that other species will also lend themselves to commercial utilization. Fortunately, the parasites of a closely similar host species, the oriental fruit moth, are being given a great deal of attention by Dr. Alvah Peterson, of the U. S. Bureau of Entomology, and others. The results of these investigations are likely to be also of great value with the codling moth, since the two species have many parasites in common.

A survey of the voluminous literature dealing with the life history of the codling moth would seem to suggest that we already possess all the information about the species in various sections that we need to know. In a narrow sense, particularly if present control methods continue in vogue, this is true. The time when the various stages will appear can now be predicted much more closely than the average orchardist can

*) 1927. Siegler, E. H., Brown, Luther, Ackerman, A. J., and Newcomer, E. J., Chemical Treatment of Bands as a Supplemental Control Measure for the Codling Moth; in Journ. Ec. Ent. Vol. 20, p. 699—701.

**) 1927. Flanders, Stanley E., Biological Control of the Codling Moth; in Journ. Ec. Ent., Vol. 20, p. 644.

apply the sprays, with delays occasioned by the numerous factors which normally govern orchard operations. This becomes particularly true when applications multiply to the point where spraying is in progress practically all of the time from petal fall until midsummer, or even later.

In a broader sense, however, we have only too little information about the species, and much of the present information would take on added significance if it were reworked and correlated with the various climatic factors which may have an influence. The influence of temperature on the codling moth is reasonably well established, that of humidity somewhat less so, and many other factors are not at all understood. For instance, what is the effect of intense sunlight on the well-being of the species? Is the well-known vigor of the codling moth in some of the arid sections of the West due entirely to high temperature and low humidity? Or is the intensity of the sunlight in those cloudless regions also an important factor? It is well known that temperatures below 62° F practically prevent oviposition, but during long periods of cloudy or rainy weather oviposition often seems to be considerably reduced, even when temperatures are sufficiently high to permit free egg-laying. Is light a factor in preparing the moth for oviposition? These and countless other queries can be answered only by careful intensive quantitative work. The practical bearing of these points is rather obscure in many cases, but, as already stated, we cannot know too much about the species.

Mention has already been made of Hough's work with apparently resistant strains of the codling moth. This work is being continued by Dr. Hough and by other investigators. While there seems little doubt that different strains of the species differ in their ability to thrive in the presence of a spray covering of lead arsenate, we are yet in ignorance as to the exact reason for the differences. It has not yet been absolutely demonstrated that these so-called resistant worms are surviving the actual ingestion of poison; differences in feeding habits may explain the differences in results with the various strains of worms.

The habits of the insect are also receiving further scrutiny. Mention has already been made of studies of the habits of mature larvae in search of cocooning quarters, with a view to placing banding and similar practices on a firmer foundation. The habits of the moths, particularly their reactions to various stimuli, are also receiving attention. A recent illustration of our lack of knowledge in this respect is the successful attraction of moths to fermenting fruit juices, in the face of statements in the literature of the past forty years that such baits are not attractive. While the use of baits is at best only an auxiliary control measure, the simple change in their position from close to the ground to high in the tree made a radical difference in the number of moths caught, and suggested information about the habits of the moth of which we had been in complete ignorance.

The experimental methods used in testing insecticides and other means of control are being scrutinized as never before. An indication of the recognition of the shortcomings of field plat work may be seen in the laboratory methods worked out by Dr. R. H. Smith, of the University of California and by Mr. E. J. Newcomer, of the U. S. Bureau of Entomology, in which newly hatched worms are transferred directly to sprayed apples. This method

eliminates the variation in infestation which in the field often leads to false conclusions. This method permits the testing of a much greater number of materials and combinations during the season than is possible in the field, and is also extremely flexible, permitting the immediate following of leads which develop in midseason. This method, however, gives little information as to the adhesiveness of materials, and information of this nature must be obtained in other ways. In fact, all information obtained in the laboratory must be confirmed by tests in the field before recommendations may be made to growers.

In the field, the experimental methods followed need further study before they may be properly evaluated. In laying out an experiment, shall the plats be so small that they may be all included in a comparatively small area, and presumably subject to a fairly uniform infestation, but run the risk of vitiating the results because of migration of the moths? Or shall they be large enough to permit the making of counts at a sufficient distance from the margin to overcome the influence of migration, but at the same time run the risk of encountering a wide but unmeasurable variation in original infestation? Your speaker will confess that he does not know the answer to this question.

In estimating results, what procedure shall be followed? How many apples constitute an adequate sample? How shall these samples be selected? Is it desirable and practicable to make separate counts on first brood infestation and infestation by worms of later broods? Shall record be made of the total number of injuries in heavy infestations, where many apples are attacked by several worms?

In this analysis, the science of mathematics is proving a valuable working tool. As with all sharp-edged tools, the mathematical analysis of experimental data is capable of serious misuse and, as with all complicated machinery, is hard for most of us to understand. The proper use of statistical methods, however, is extremely valuable in giving a worker confidence in his results. What is fully as important, it may cause him to reject tentative conclusions which are not really supported by the data. If this procedure had been followed in the past, much of the disagreement and conflict between various workers would never have occurred.

This, in a very brief and fragmentary way, outlines the codling moth problem as it exists in North America today. In addition to being a problem of great economic importance, it is one of intense scientific interest. It is a problem of increasing complexity, and every new point established seems to suggest a half dozen others which need investigation. The very complexity of the problem is stimulating a greater cooperative effort-cooperation among the various entomological agencies, and between entomologists and other scientific groups: chemists, plant physiologists, horticulturists and many others.

Lubricating Oil Sprays and the Pear Psylla Problem.

W. A. Ross, Dominion Entomological Laboratory, Vineland Station, Ontario.

In North-eastern America the control of the pear psylla, *Psylla pyricola,* has proved to be one of the most difficult problems which orchard entomologists have had to face. The problem has been to discover remedial measures which, in the hands of orchardists, will reduce a three to four-brooded, very prolific and most destructive insect to comparatively insignificant numbers, and which at the same time are sufficiently simple and economical to be adopted generally by fruit growers.

For several years we in Ontario pinned our faith to and recommended an egg spray of lime sulphur 1—7 or 9 and nymphal sprays of nicotine sulphate, but some six or seven years ago we were very reluctantly forced to the conclusion by the experience of orchardists that this treatment was not sufficiently effective and economical. The majority of fruit growers, with orchards subject to *Psylla* attack, failed to prevent serious injury in seasons favorable for the insect, and consequently some of them became so discouraged that they threatened to take out their pear trees. At this time there was an insistent demand from pear growers for a spray material much cheaper and more effective than nicotine sulphate, and for this reason an investigation on the possibility of using cheap lubricating oil sprays, directed against the overwintering *Psylla* adults, was commenced in 1924. Comparison experiments with 2% and 3% lubricating oil emulsions (soap, calcium caseinate and Bordeaux) and lime sulphur-nicotine sulphate (10 gallons of lime sulphur, 10 lbs. hydrated lime, 1 pint nicotine sulphate, 90 gallons of water), applied in early April just before egg laying commenced, very clearly indicated that the oil was more efficient than lime sulphur-nicotine sulphate, and that a concentration of 3% oil was necessary. The most striking feature of the experiment, however, was that, in a season when the *Psylla* was abundant and destructive, the trees sprayed with 3% oil required no further treatment; right up to the time Bartlett pears were picked the *Psylla* was scarce on them and caused no appreciable injury. In 1925, experiments with lubricating oil sprays were carried on in some twenty-two orchards scattered through the main pear growing district from Burlington, Ontario, to the Niagara river and all very subject to *Psylla* injury. In one orchard comparative tests with 3% Bordeaux, calcium caseinate, milk, albumen and soap emulsions were conducted; in another 3% and 4% Bordeaux oil sprays were compared; in 7 orchards 3% calcium caseinate oil was used; and in all the others the trees were sprayed with 3% Bordeaux oil. In the two orchards where the comparative tests were run, all the emulsions gave equally good results, and the 4% oil spray gave no evidence

of being superior to the 3% spray. Furthermore, in all the orchards with the exception of two, the one application of oil gave excellent commercial control of the *Psylla*. Up to the middle of September, when our last observations were made, the insect was scarce in oil sprayed orchards; there was no serious leaf spotting, no defoliation and no smutting of the fruit. The results, to put it mildly, were remarkable. On the other hand, in orchards which we used as checks and which had received: (1) a pre-blossom spray of lime sulphur and a post-blossom application of nicotine sulphate, or (2) at least a post-blossom application of nicotine, the *Psylla* was very abundant and injurious. In such orchards, generally speaking, the insect was abundant by mid-July; serious injury was conspicuous in early August; by the end of the month considerable defoliation had taken place, and the trees and fruit were smutty.

And now the question arose, how are we to account for the remarkable results secured from one application of oil? The oil destroyed large numbers of the overwintering "flies", but it was apparent that the percentage of mortality due to this was not sufficiently high to account by itself for the remarkable degree of control. Orchard observations indicated that in addition to killing adults at the time of spraying, the oil continued to function as an insecticide for sometime after it was applied. It was noted that, when the oil sprayed trees were wet with dew or rain, some of the "flies" which survived the application were killed by the oily film on the trees, and that some of the newly hatched nymphs were destroyed by the oil on the wood; but all observations indicated that the most important residual effect of the oil was the prevention of egg laying. With the object of shedding some light on the residual action of lubricating oil sprays, the following experiments *) were conducted in the laboratory during February and March 1926:

Experiment A: Gravid adults were confined from 3 to 7 days in large celluloid cages with two oil sprayed and two unsprayed pear seedlings in each cage. In nine tests, 3,200 eggs (98.4%) were laid on the unsprayed and only 51 (1.6%) eggs on the sprayed wood.

Experiment B: 55 adults were confined for four days in a celluloid cage on five unsprayed and five sprayed pear twigs, and all the eggs, 703, were deposited on the unsprayed wood.

Experiment C: In each of six tests six pairs of adults were confined for 10.2 days on sprayed wood, and another six pairs on unsprayed wood. In the "check" cages 349 eggs (99.1%) were laid, whereas in the case of sprayed wood only 3 eggs (.9%) were found.

Experiment D: 150 adults were confined for twelve days on two sprayed seedlings in a large celluloid cage. At two-day intervals, unsprayed wood was introduced into and was left in the cage for two days. The psyllas had access to oil sprayed wood for twelve days and to unsprayed wood for only six days, yet in spite of this, 97.7% (833) of the eggs were deposited on the latter.

The results secured from these experiments clearly demonstrated that the oil spray has a most important residual action, to a very marked extent

*) In all these experiments a 3% Bordeaux oil spray was used.

it prevents egg-laying and unquestionably it is this residual action which explains why lubricating oil sprays have given such clean-cut results.

In 1926 the lubricating oil emulsion method of combating the pear *Psylla* was adopted by the majority of pear growers with orchards subject to severe *Psylla* attack, and in all cases which came under our observations excellent commercial control was secured.

Our experience with oil spraying the following year, that is 1927, was most interesting and instructive. That season the outbreak of *Psylla* was the most extensive and by far the most intensive we have had in Ontario. The insect was abundant and destructive even in orchards heretofore not subject to injury. The oil spray method of control was therefore subjected to a most severe test, and it is gratifying to record that, where applied prior to egg deposition, or at least before any appreciable egg-laying was done, the oil emulsion, supplemented with a late application of nicotine sulphate, gave excellent control. For example,, in a Burlington Kieffer orchard sprayed before oviposition commenced, the one application prevented any serious injury and in all probability further treatment would have been unnecessary, but, as an insurance against smutting of the fruit by the honey-dew fungus, the trees were sprayed again shortly before the fruit was harvested with nicotine sulphate and soap. As late as October 21st no defoliation had taken place in this orchard; something remarkable in a *Psylla* year like 1927. Lubricating oil sprays gave satisfactory results where they were applied at the right time, but unfortunately very many orchardists put on the spray too late, and consequently failed to secure control. The exceptionally wet and soft condition of the soil in late March and early April made it impossible in many cases to spray until egglaying was well under way, and in other orchards the application was made too late, because the growers did not fully appreciate the necessity of early spraying. In late-sprayed orchards the infestation was heavy in July, and by the end of the month serious defoliation had taken place. Our experience that season certainly demonstrated very forcibly the vital importance of pre-oviposition spraying.

This spring practically all pear plantings of any consequence were sprayed with lubricating oil, and at the present time all the indications are that in most orchards no further treatment will be necessary.

And now a word about the kinds of lubricating oil which have been used for *Psylla* control in Ontario. Cheap oils costing about thirty cents per Imperial gallon and with characteristics approximately the same as those given below have proved to be very satisfactory from all points of view.

Gravity at 60° F . . . . ! . . .	24 to 26 A. P. I.
Flash Point (open cup)	360° F (minimum)
Viscosity at 100° F	170 to 220 seconds (Saybolt)
Volatility (loss at 105°—110° C after 4 hours	0,41 %
Pour and Solid	40°—35° C.

Various emulsifiers, soap, Bordeaux mixture, calcium caseinate, etc., have been used, but the only one which has been generally adopted by growers is Bordeaux mixture. Bordeaux mixture is the favorite emulsifier for the following reasons: Bordeaux emulsions are easily prepared; they mix readily in hard water and make a smooth, uniform spray; the materials

used in making them, copper sulphate and lime, are old friends of the farmer and are always readily available. The oil emulsion used in Ontario is prepared according to the following formula:

Lubricating oil	1 gallon,
Water	1 gallon,
Copper sulphate	2 ounces,
Hydrated lime	2 ounces.

At the outset of the investigation on lubricating oil sprays, there was some fear that annual applications of oil would result in injury to the pear trees, and for this reason particular attention has been given to the effect the emulsions have on the trees. Up to the present time dormant applications of 3% oil sprays, of the type recommended by us for pear *Psylla* control, applied annually, have caused absolutely no injury to pears. In connection with this, it is very reassuring to find that a large pear orchard near Beamsville which has now been sprayed with oil for five successive years has borne larger and more regular crops than any other planting in our pear growing sections. Furthermore, in experiments with 10% and 20% oil sprays, three annual applications of 10% caused no damage and in the case of the 20% spray no injury was apparent until the third year when a considerable number of the leaf buds were killed. In view of the foregoing we have, therefore, no hesitation in recommending annual dormant applications of 3% on pear trees.

The Larch Sawfly and Forestry.*)

Samuel A. Graham,

Associate Professor of Forest Entomology, University of Michigan.

In the Lake States and in Eastern Canada the management of the swamp forest presents a difficult problem. These forested swamp areas are extensive throughout the forested parts of the glaciated region of North America, and, like similar swamps in Northern Europe, they have been formed by the filling up of lakes with vegetation. In the Lake States alone the area of forested swamp land is put at 5,000,000 acres (U. S. D. A. Bull. 1496). This is certainly a very conservative estimate. A part of this great swamp area is of such a nature that it can and ultimately will be drained and used for agricultural purposes, but by far the greater part can best be used for the purpose of producing wood.

In the Northern swamps a number of tree species are found. In the calciferous swamps white cedar, *Thuja occidentalis*, is often the predominant tree, although tamarack, *Larix laricina*, grows well on such sites. In the acid swamps, however, almost without exception either tamarack or black spruce predominate.

These swamp trees grow slowly and for that reason the financial return per acre is even at best comparatively small. Obviously this small expected return precludes very intensive management, unless such management materially increases the rate of growth. In certain instances, at least, growth may be materially stimulated by superficial drainage. But even though such drainage might be a decidedly profitable expenditure insofar as increased growth rate is concerned, it would be a decidedly poor investment, unless the forest can be adequately protected from the attack of insects.

Up to the present time both black spruce and white cedar growing in the swamps have been comparatively free from insect injury, except for a few local outbreaks of the spruce budworm. Tamarack, on the other hand, has suffered tremendously from the ravages of the larch sawfly, *Lygeonematus erichsoni*.

If it were not for the injury caused by this insect, tamarack would be a very desirable tree in the northern swamp forest. It reproduces itself very readily under swamp conditions, it grows more rapidly than either spruce or cedar, and although tamarack wood is not so valuable as spruce, nevertheless it possesses many excellent qualities that make it very useful.

---

*) The work on the larch sawfly problem upon which this paper is based is being conducted co-operatively by the Bureau of Entomology, the University of Michigan and the University of Minnesota.

Under present conditions, however, tamarack as a swamp forest tree is of little value, because the sawfly does not give it an opportunity to attain full development. Before a tree can reach merchantable size, it is usually so severely injured that it is almost worthless.

Perhaps it would at first appear that tamarack should be excluded from the swamp forest of the future, but such a drastic measure is not feasible, because of the tremendous areas now occupied by young tamarack. These stands cannot readily be converted to forests of other species. Therefore on the control of the larch sawfly hangs the future of millions of acres of swamp land. If we can control the sawfly, these forests can in all probability be handled easily and profitably; but if we cannot control the sawfly, tamarack will cease to be an important forest tree, and it must either be replaced with other species or the land which it occupies will continue to be an unproductive waste.

History of the Larch Sawfly in America.

For the information of those who may not be familiar with the activities of the larch sawfly a brief summary of its history in America may well be inserted here.

It was first observed in America near Boston, Massachusetts, in 1880. In the years following it defoliated larches throughout Eastern United States and Canada. Early in the twentieth century it made its appearance in epidemic numbers in the Lake States and Western Ontario. The fact that the sawfly appeared first on the Atlantic seaboard and later was observed farther west has been accepted as evidence that the insect was introduced into America from Europe. This assumption is apparently further substantiated by the fact that since 1880 outbreaks of the sawfly have occurred so frequently that the tamarack throughout the infested region has been unable to grow satisfactorily, a condition that would effectively have prevented the development of the fine forests of large tamarack that were common prior to that time. In the first years of the twentieth century, when the great outbreak occurred in the Lake States, the tamarack forests were apparently in excellent condition. The outbreak, however, resulted in the complete destruction of over 60% of all the tamarack over three inches in diameter. The smaller trees as well as the larger were heavily attacked and severely defoliated by the sawfly, but most of them possessed a sufficient reserve of food or sufficient vitality to survive, although the tops were killed in many instances. Since this outbreak the survivors have partly recovered and much tamarack reproduction has sprung up. But the sawfly is still present in alarmingly great numbers and is preventing satisfactory development of the trees.

Thus circumstantial evidence indicates that the larch sawfly was introduced into America from Europe; but there is other evidence that seems to show that it may be a native insect. The most important evidence on that side is the record of growth found in the annual rings. In the oldest trees there may be observed periods of reduced growth, extending one hundred years or more into the past, that cannot be explained either by suppression or by unfavorable weather conditions.

During the past century may be found four distinct periods of reduced growth; one beginning about 1835—1840, one between 1850 and 1860, one between 1870 and 1885, and the last and most severe between 1906 and 1915.

Other tree species growing nearby show no such periods of reduction, therefore we are justified in concluding that weather conditions are not responsible. Furthermore, the falling off in growth rate is unlike that caused by suppression. It comes suddenly and after a period of slow growth increases gradually. If the reduction were due to suppression, both the reduction and subsequent recovery would have been gradual. The ring picture, however, is very similar to that produced by defoliation. Therefore it seems practically certain that the tamarack forests have suffered repeatedly from defoliation during their period of growth and it seems probable that the larch sawfly was the species responsible.

If this conclusion is correct then the larch sawfly has been present for at least a century or more and is very likely a native insect. At first thought it seems remarkable that this destructive species escaped notice until such recent times, but in view of the fact that tamarack swamps held little of interest in the early days of this country, extensive injury might easily have been overlooked. Even in Europe the sawfly escaped attention until the first half of the nineteenth century. So perhaps in a new country like America it is not surprising that it escaped notice for a long time.

Two Ways of approaching the Sawfly Problem.

Whether or not the larch sawfly is a native of America may appear at first glance to be a purely academic question. It is more than this, however. If it is native, our method of attacking the problem will not be the same as if it were an introduced species. If it is native, we may expect to find satisfactory means for its control by studying the insect in America without any special European investigations. If, on the other hand, it is introduced, a study of European conditions and the introduction of the most effective European parasites and predators might be of material assistance in arriving at a satisfactory solution in America.

Hitherto the larch sawfly has been regarded by most entomologists as being an introduced species. Years ago Hopkins suggested that it might be a native insect, but neither he nor others followed up his suggestions. The assumption that the sawfly came to this side of the Atlantic from Europe has exercised a marked influence upon previous studies of this insect, notably those by Hewitt. Both fungous and insect parasites have been introduced from abroad, in some instances only to find later that they were already present in America. Although we cannot say positively that the sawfly is native, there is at hand sufficient evidence to justify the assumption that it probably is. Therefore in the present work we are studying the sawfly as we would any other native pest.

We have already pointed out that the swamp forest is capable of producing only a comparatively low financial return per acre. This situation requires that the expense involded in controlling the sawfly be

kept down to the minimum. Therefore the use of any direct method of control is practically impossible because of the expense that such operations would involve. Instead of using direct methods we must fight the sawfly by indirect means.

In past tree generations tamarack grew to maturity in our swamps, presumably in spite of the larch sawfly. Why are the trees of the present generation suffering so much more from this defoliator than did the generations preceding? If we were able to answer this question, we probably should then be in a position to control the sawfly. If we knew the conditions that prevented the sawfly from destroying previous tamarack forests before the trees reached maturity, we might be able to simulate those conditions now. But, unfortunately, this information is not available. We can, however, by studying the effect of various environmental factors upon the sawfly, determine the conditions that are favorable and those that are unfavorable for the rapid multiplication of the insect, and on the basis of this information so handle our forests as to maintain conditions as unfavorable for the sawfly as possible. Thus sawfly outbreaks might be prevented or at least reduced in severity.

It was with this end in view that the present work was undertaken. The project is far from completed, but several points have been established and many suggestive results have been obtained that encourage one to believe that the control of the larch sawfly is by no means an impossibility.

The first step in this work is to determine as completely as possible the effect of the various environmental factors, both physical and biotic upon the sawfly. The next step is to apply our knowledge so obtained in producing in the forest unfavorable conditions for the sawfly. So far the work is still in the first stage. Some of the results obtained will be set forth here, not with the idea of presenting a completed picture, but to show some of the possibilities that are developing from this line of investigation.

Hibernation Experiments.

One series of experiments was designed to determine the effect of various factors upon the ability of the insect to pass the winter and emerge successfully the following spring. Some of these hibernation experiments have been practically completed. They indicate that, while in the cocoon, the sawflies are subject to many vicissitudes and, unless they are placed under favorable conditions, are unable to survive and emerge. The physical factors, heat and moisture, appear to be especially important during that period. The cocoons must be under cool moist conditions if the insects are to pass the winter successfully. The results so far obtained are summarized in the following paragraphs.

On the surface of the moss beneath the trees in the swamps we have found that only about 25 to 30% of those that spin cocoons succeed in emerging as adults even though the moss on which they are lying is continually moist. When buried in the moss, however, conditions are more favorable and more of the insects survive. When buried from one to two inches beneath the surface, an emergence of from 32 to 61% with an average of 51% was obtained in our experiments. When buried deeper

than two inches, he percentage of succesful emergence decreases, perhaps because of excessive moisture. Even under the most favorable conditions in the moss the winter mortality is high.

Under tamarack on high ground, however, the mortality is much higher than in the swamp. On the surface of the needle litter beneath tamaracks growing on the upland practically no emergence occurs. The insects within the cocoons are, almost without exception, killed by excessive heat. Even beneath an inch of tamarack needles only about 10% survive.

From this it seems probable that if tamarack is grown on well drained soil, where temperature of the surface layer would not be held down by a heavy growth of surface vegetation and the presence of large quantities of evaporating water, the percentage of sawflies passing the winter successfully would be extremely low. Inasmuch as tamarack thrives better on drained soil than in the wet swamps it seems possible that superficial drainage, by drying out the surface layers of the moss, might do much to protect the trees from sawfly injury and at the same time stimulate the trees to more rapid growth.

Observations indicate that excessive moisture is also unfavorable for the larch sawfly, and as a result the tamaracks growing in excessively wet swamps suffer less from the attack of this insect than do those growing in swamps that are only moderately wet. For instance, it was observed that some stands of tamarack escaped serious injury during the great outbreaks of the larch sawfly previously mentioned, and an explanation of their comparative immunity was sought. In all such stands examined it was found that the ground cover was quite different from that of most tamarack swamps. Instead of *Sphagnum* there was a growth of *Carex* interspersed with patches of marsh marigold, *Caltha palustris*. Both these plants require considerable water and their presence indicates a much greater degree of surface flooding than is the case in those swamps where *Sphagnum* and heaths predominate. It seems logical to conclude that excessive water, especially during the spring and early summer, is unfavorable for the larch sawfly. Experiments designed to test this theory have been planned.

Other factors than heat and moisture reduce the number of sawflies that succeed in surviving the cocoon stage. For instance parasites destroy a certain number. During the past few years the percentage of parasitism has been very low, less than 10%. The results of this season's investigations (1928) will show a decided increase in the amount of parasitism, judging by preliminary studies. Past observations lead us to believe, however, that parasites are not a very reliable check upon the sawfly, because under epidemic conditions the sawfly damage is usually excessive before the parasites multiply to the point of real effectiveness. Each year, however, they destroy some of the host and to that extent are of course a help.

The organism that appears to be most valuable as a destroyer of cocooned sawflies are the mice. These animals are often very abundant in the swamps and during late summer and autumn find and destroy great numbers of sawfly prepupae. They burrow through or dig down into the moss or litter beneath the trees in search of the cocoons. These

they open, and eat the prepupae within. In some swamps 95% of the cocoons were found to have been opened by mice, and even in the swamps where mice were the least numerous over 50% of the cocoons had been opened by them. Our studies showed that the mouse population varied in density with the character of the ground cover. They were most abundant where the ground cover was most varied, and least abundant where the ground cover was composed primarily of grass and sedges.

The effectiveness of mice as a check upon the sawfly suggests the advisability of maintaining, in the tamarack forests, conditions favorable for these animals. If by increasing the variety of the ground cover it is possible to maintain a larger mouse population and thereby bring about the destruction of a greater proportion of the sawflies, another means of creating conditions unfavorable for sawfly multiplication suggests itself. It is a well known fact that as a swamp becomes drier, the variety of the surface vegetation increases. Thus here again superficial drainage might produce beneficial results.

Factors affecting Larval Sawflies.

From the preceding discussion we have seen that during the time that the sawfly is within the cocoon a large proportion of them is killed either by mice, other entomophagous organisms, or by unfavorable physical conditions of the environment. Many individuals, however, that hatch from the egg are overcome by environmental resistance during the larval stage and fail to reach the cocoon stage. During the present season we have been conducting special studies to determine what factors are most important in destroying the sawfly larvae. The data collected in the course of this work have only been analysed in part, but certain conspicuous results may safely be presented here.

The method used in studying the effect of environmental resistance upon sawfly larvae was very simple. Tamarack tips containing eggs were selected for observation and were examined from day to day as the eggs hatched and larvae developed. The gregarious habits of the larch sawfly coupled with the fact that the larvae move about very little, except as scarcity of food requires them to transfer their activities to an adjoining branch, made it possible to follow the development of the insect throughout the larval period without necessitating the use of cages. By counting the number of larvae from time to time it was possible to determine when and why reduction in numbers occurred.

One of the factors that resulted in a reduction in the number of sawfly larvae was the effect of heavy rains. This influence was especially important while the larvae were in the first instar. A heavy rain just after they hatched in one instance washed off almost 50% of the larvae. In another group under observation when the larvae were a day old only about 20% were washed off by the same storm. After the first instar, however, the effect or rain upon the larch sawfly is not great. Less than 10% of the larvae in the second and later instars were washed from the trees by a heavy wind and rain storm during which there were almost two inches of precipitation in less than two hours.

In most of the groups under observation the larvae during the second and third instars were only slightly affected by factors of environ-

mental resistance. During this period they suffered little from the effect of rain and comparatively little from the attack of predators. During these instars the habits of the larvae protect them from the attack of birds. They feed upon the distal fascicles first and are therefore, during the early instars, feeding upon the very slender twigs which are difficult for most birds to reach. Occasionally some small bird, such as the chipping sparrow, found a group of these small larvae and would destroy them all, but such occurrences were rare. In spite of the fact that four or five nesting birds per acre occurred in and near the swamps, the birds were seldom observed to feed upon the small sawfly larvae.

Later, in the fourth and fifth instars, when the foliage on the slender twigs has been eaten the larvae are much more susceptible to the attack of birds, because they are then forced to seek their food upon the older, heavier twigs. There the birds can reach them easily. In this later period numerous bird species were observed to feed freely upon the sawfly. Some of these were the white throated sparrow, the black capped chickadee, the Maryland yellowthroat, the cedar waxwing, and the Wilson thrush.

During the later larval stages insect predators appeared in considerable numbers and fed freely upon the sawfly larvae. Several species of *Coccinellidae* and *Pentatomidae* were frequently observed in the act of feeding upon them. The combined effect of birds and other predators, operating primarily during the later instars, fourth, and especially during the fifth, accounted for some 25% of the original number of larvae. At the present time it is impossible to say whether or not ways may be found to improve conditions for these enemies of the larch sawfly so as to bring about an appreciable increase of their numbers, but it is perfectly possible that this end may be accomplished when we come to know more about these beneficial organisms than is now know.

With the accumulation of sufficient information concerning the larch sawfly and its reaction to both the physical and biotic factors of its environment we shall be able to determine with reasonable certainty the possibility of sawfly control in the swamp forest. At the present time the modification of the physical environment by means of superficial drainage appears to offer the greatest promise. On the other hand, however, we have seen that excessive surface water is also unfavorable for the sawfly and in some instances flooding may offer a feasible means of protecting tamarack forests from injury. One thing is clear, however, from both experimental and observational data. This is that physical conditions as they now exist in the great majority of tamarack swamps are decidedly favorable for the larch sawfly. Unless it is possible either to modify these physical conditions so as to make them less favorable, or to increase biotic resistance for the sawfly by favoring its natural enemies, the future of the tamarack forest is very dubious. From the results so far obtained, some of which have been presented in this paper, we are confident that means of accomplishing the desired results can and ultimately will be found.

The Measurement of the Effects of Ecological Factors.*)

Professor Royal N. Chapman, University of Minnesota.

Ecology is bound to become quantitative. Many of us are observing this inevitable tendency with regret. There is a feeling that the wonders of observational natural history are to be brushed aside by the cold dry calculations of a mechanistic mathematics. To those who hover between their doubts of the validity of any measurements of living systems and their admiration for the vast accumulation of important facts which have been gained by purely observational natural history, let it be said that any well balanced scientific mind must recognize that the results of observation form the prerequisites for quantitative work, just as arithmetic is a prerequisite for algebra and calculus.

No one has appreciated the qualitative facts of natural history or admired the ingenuity of the observer and the observed more than I. It must also be confessed that a genuine feeling of regret has come over me more than once as I have turned from observing animals under the ephemerally fluctuating yet enticing conditions of lakes and forests, to the laboratory where conditions are fixed and controlled with such bare rigidity. Doubts also have often come, during hours of discouragement, when pondering over the difficulties of quantitative expression and calculation in connection with complicated ecological phenomena.

But the quantitative trend is both logical and inevitable. With the continued accumulation and evaluation of facts, nothing is more certain than ultimate success.

The urgent needs are, first, more accurate measurements of environmental factors and the populations which make up the natural associations, and, in the second place, better methods of evaluating the measurements of the factors. The search for such facts is expensive in both time and money. For this reason it is worth while to take some time for considering the possibilities of measuring environmental factors in order that we may better judge the type of facts most worth while.

Even in the field of physical science the most exact measurements are more or less indirect approximations of the effect of factors on some standard substance. Fahrenheit's temperature scale adopted an approximation to the temperature of the human body for one of its fixed points. However, Celsius's freezing and boiling points of water proved much more satisfactory, and we usually visualize them in the expansion

*) Published with the approval of the Director as Paper No. 194 of the Miscellaneous Series of the Minnesota Agricultural Experiment Station.

of mercury under conditions in which only the one factor of temperature is varying.

An idea of the complications which arise when several factors are varying can be gained by a study of the international critical tables. Here one is also impressed with the fact that a great amount of information can be clearly and briefly expressed in tables and graphs when quantitative data are available. Such possibilities are in striking contrast with our field of entomology.

The history of the measurement of the effect of factors in the field of biology has centered in physiology and the ecologist has followed the precedent set by the physiologist. The tendency has been to resolve the ecological investigations into physiological investigations and these in turn seem to have had as their object the resolution of all phenomena to physical processes. This method has lent a great impetus to biological research, has done away with much vagueness of thought and has pointed the way to definite progress.

We now know that each physical factor of the environment may present an optimum condition for any species, above and below which it may extend to the limits of toleration. The magnitude of the variation between the optimum and the limits of toleration is a relative matter. Some factors vary so little in nature that they are always very close to the optimum. When two factors are involved we may express the effects on a two dimension surface. As more factors become involved the situation becomes more complicated until we might visualize our organism in a sphere, the center of which represents the optima of all factors, the various diameters representing the various factors, and the surface of the sphere marking the limits of toleration of the entire environment beyond which the organism can not exist.

Without any intention of depreciating the value of such stimulating physiological research, it may be fair to ask the question as to whether such work gives the information most needed in our field and whether there is not a possibility of developing ecological methods of measuring the effects of environmental factors.

The quantitative studies of biotic factors have rather naturally resolved themselves into a consideration of the effects of competitors, predators, and parasites on the populations of the organisms under consideration. The effects of these factors can thus be evaluated in terms of the population and are, therefore, subject to calculation and experimentation in terms of populations which need no translation to discover their ecological significance.

The theoretical possibilities of equilibrium of populations under various combinations of biotic factors have been explored by Thompson (1923), Pérès (1927), and more recently by Volterra (1926—27). In the case of Volterra it is interesting to see one of the most eminent mathematicians of the day turning his attention to the equilibrium of biotic systems. We can feel a sense of certainty with regard to the theoretical possibilities of competition, parasitism, etc., and the door is wide open for experimental research in checking the conditions which obtain in nature against the theoretical possibilities, and testing the laws of biotic fluctuations which Volterra has deducted from purely symbolic reas-

oning. He assumes "coefficients" of population growth and "exhaustion" which parallel the conception of biotic potential and environmental resistance (Chapman 1925).

In such considerations we become acquainted with phenomena of a different order from those considered by the physiologist in that we are concerned with systems in which the individual organisms are the units, just as the organs, tissues and cells are the units of the organisms which the physiologist studies. It cannot be said that one of these systems is more fundamental than the other. Respiration, oxidation, or any other physiologic phenomenon represent a sort of algebraic sum of a multiplicity of physical and chemical processes, just a any function of a population represents the summation of many component phenomena.

Since it is possible to evaluate biotic factors as environmental resistance or as "coefficients of exhaustion" why should not the physical factors be evaluated in the same way? We have been inclined to follow the technique of the physiologist and reduce our physical readings to such terms that other ecologists can not understand us and to feel secure in the unapproachableness of our technical position. Might it not be better to evaluate these factors in terms of the influence that they have on the trends of populations so that they can be understood and appreciated?

When both physical and biotic factors are evaluated in terms of the effect upon the trend of the population, we have them all expressed in terms of a common denominator and the combined effects can be calculated. This is very significant, because it means that we can determine the effect of isolated individual factors and compare them with the same factors in various combinations.

The progress of experimental work with Tribolium to demonstrate the practicability of this hypothesis has already been reported on (Chapman 1928). Present results seem to indicate that any significant factor can be detected and measured. Even disturbances in the routine technique are registered in the population trends.

What this method can do in synthetic laboratory experiments, it can do in practical field work in the analysis of environmental factors. Quantitative data must be obtained as a basis for calculating the populations. A determination of the rate of reproduction must also be arrived at. It is then necessary to measure the rate of reduction of the population and make a careful study of the factors correlated with this reduction in population.

When the number of females which are present at the start of the season is known it is possible to calculate the potential number of eggs. After oviposition the number of eggs which are actually present must be determined. The difference between the potential number of eggs and the actual number will then be a measure of the environment up to this time. In a similar manner the reduction of the population during each instar of the larval life can be taken as a measure of the effects of the environment during each of the stages.

Nothing can ever substitute for painstaking study, but the results of investigations can be made more intelligible by expressing them all in the same terms: the reduction in the population. Having a common denom-

inator for all environmental influences it is possible to make a direct comparison between them.

This in itself is not an easy task. All of the complications which Jacobs (1928) has pointed out in connection with the effect of temperature on physical systems which are approaching a state of equilibrium apply also to populations which are approaching equilibrium. But so long as we are interested in insect populations and these are the facts concerning populations, there is nothing to do but make ourselves acquainted with these facts. Just as the physical chemist deals quantitatively with systems composed of compounds, elements, ions and colloidal particles, so the physical ecologist must deal with systems composed of genera, species, associations, consocies, and individuals.

Literature.

1. Chapman, Royal N. — Animal Ecology with Special Reference to Insects. 1925. Minneapolis.
2. id. — The Quantitative analysis of Environmental Factors; in Ecology 1928/29, pp. 111—127.
3. Jacobs, M. H. — The Complex Nature of the Effects of Temperature on the Rates of Certain Biological Processes; in The American Naturalist 1928, 62, pp. 289—297.
4. Pérès, Joseph. — Une application nouvelle des Mathématiques à la Biologie: La théorie des Associations Biologiques; in Rev. Gén. d. Sci. pures et appl. 1927, 37, pp. 295—300, 337—341.
5. Thompson, W. R. — La Théorie Mathématique de l'Action des Parasites entomophages; in Rev. Gén. Sci. pures et appl., 1923, 34, pp. 202—210.
6. Volterra, Vitio. — Variazioni e fluttuazioni del numero d'individui in specie animali conviventi; in Mem. R. Accad. Naz. Lincei Cl. Fis. Mat. e Nat. 1926, 2, pp. 31—112.

Discussion:

S. A. Forbes: I do not think that we ought to let this remarkable paper pass without an expression of our appreciation of its value as a fresh and important contribution to scientific method in Ecology.

To get secure and dependable results in the investigations of our complex problems, especially difficult as they are because of the variability of their elements, is a serious and perplexing task, and we may feel encouraged at the advances in method which are being brought forward by the younger generation of ecologists, who have been thoroughly trained for their work, and are able to utilize methods with which we, of my generation at any rate, were unacquainted, or in which we were at best unpractised. Those of us who have been often perplexed to know where, in the course of our ecological inquiry, we might stop our accumulation of statistical data and draw our conclusions from the fragments studied, with reasonable assurances that they were applicable to the whole, must be deeply interested in Dr. Chapman's paper, and ready to apply, with grateful alacrity, the product which our younger colleagues are contributing to the common stock.

An Enquiry concerning the Natural History of the White-pine Weevil (Pissodes strobi).

T. Cunliffe Barnes, Bussey Institution, Harvard University, Cambridge, Mass.

(Abstract.)

This investigation was made possible by facilities afforded by the Entomology Department at Cornell University, the Conservation Department of New York State, and the Bussey Institution.

Certain points in the internal anatomy of the weevil have ethological significance. The immature state of the ovarian tubes of recently emerged females in late summer precludes the possibility of oviposition until the spring, at which time the tubes are much larger, flexed, and present a large vitellarium. The number of eggs maturing at one time is small, and the rate of oviposition in cages averaged only two to four eggs per diem. 150 eggs were laid by one female in May and June in three pine shoots, all of which were killed by the larvae. In pine plantations with a population of twelve females per 100 trees, 25% of the trees may lose the terminal shoot in a single season. The spermary of the recently emerged males in late summer is quite advanced, but the glands and vesicle do not enlarge until the spring.

Six Malpighian tubules are present in the larva and the adult. The ventriculus of the latter is pouch-like and evidently concerned with intermittent feeding.

The powerful flight muscles occupy a large part of the metathorax; the dorsal longitudinal and the sterno-tergal flight muscles are especially prominent.

Temperature is an important factor controlling flight activity; the minimum is circa 70° F and the optimum 80° F or above. Weevils leave the pine litter under the trees in the spring when the mean temperature rises from 40° to 60° F, and pass into a stage of summer dormancy when the mean temperature reaches 70° F in July (Ithaca). Weevils have been under observation for two years, but a high mortality obtains during the second hibernation.

Flights were made from an especially devised apparatus during May and June, and the new brood flew readily in August and September. In plantations most flights were made to near-by trees, but in an open field a weevil was followed for 100 yards, at which distance the insect was lost to view 50 ft. in the air and flying with a slight breeze. The weevil takes wing from needles on the terminal shoot and has been observed to alight on the needles of the lower branches.

The weevil is negatively geotropic and positively phototropic, and these reactions determine the locus of oviposition at the tip of the tree. If the upper part of a young pine is maintained in an inverted position the insects will oviposit at the highest point.

The larvae of the facultative predator *Lonchaea corticis* Taylor were abundant in the injured shoots, feeding on the damp frass and attacking many weevil pupae. This fly was often heavily parasitized by a small Chalcid, *Pleurotropis* n. sp. Besides the commom *Eurytoma pissodis Gir.* a number of less important parasitoids were reared from weevil larvae — *Labena apicalis* Cress., *Microbracon pini* Mues., *Rhopalicus pulchripennis* Cwfd., *Calliephialtes comstocki* (Cress.), *Eupelmus pini* Taylor and *Coeloides pissodis* Ash.

Hundreds of the larvae of the Nematode *Diplogaster* sp. were observed in the elytra of hibernating weevils, and the mature worms were found copulating in the injured pine tips in July. This Nematode lives symbiotically with the weevil, like the European *Diplogaster hylobii* Fuchs.

No special studies of control measures for the weevil were carried on, but the high weevil population found on widely spaced trees affords additional support to Dr. S. A. Graham's recommendation that pines should be set out with a density not less than 1500 trees to the acre. The random flights observed in mixtures of pine and deciduous trees help to explain the protection of pine by adjacent hardwoods.

Acalla hastiana a Destroyer of Osiers in Czechoslovakia.

Dr. Jaromir Sámal, Charles IV. University, Prague.

Acalla hastiana is one of the most abundant Tortricids and well known to all Entomologists. It occurs in Europe, Siberia and North America, with the exception of the S. European countries. The great variability of the species is well known. Spuler, in Kleinschmetterlinge Europas (Stuttgart, 1913), enumerates 13 varieties and makes the remark that we find such numerous modifications in between these varieties that we are frequently uncertain as to which of the described varieties a specimen appertains. In Fernald's Catalogue (1882) 9 North American forms are mentioned, and Forbes, in Lepidoptera of New York and the neighboring States (1923), gives short diagnoses of no less than 18 principal named varieties, many of which occur in the United States.

Nowhere in literature have I found this species referred to as destructive. Nevertheless, this Tortricid has multiplied during the last three years to such an extent in the environs of Prague and other districts of Bohemia that it has become very injurious to our willow trees. Similar reports have come from Poland. As the basket industry is very important in Czechoslovakia, especially in Bohemia, the damage done by this insect makes itself very seriously felt.

The willows of which the young shoots are used in basket-making grow in the environs of Prague along the rivers and around the fishponds. The caterpillars, in attacking the young shoots, arrest the growth of the osiers and destroy their productivity.

I can present the following observations on the life-history of this injurious species: During the last few years the varieties *psorana, mayrana* and *coronana* have been found in Bohemia. According to my observations there are two generations in Bohemia, the first flying in June and the second up to the end of September. The caterpillar draws together, by means of some threads, several leaves at the top of the shoot, so that they form a very solid cluster. In this shelter the caterpillar hollows out the youngest leaves and the buds, and thus the growth of the shoot is stopped. The sprout becomes thin and has the appearance of being burned by fire or frost. Here the change into the chrysalis takes place. The pupa is found in the top of the cluster of leaves in such a position that the head of the future imago is turned upwards.

For oviposition the females fly about the young shoots and place one egg at the tip of each. The number of eggs deposited by a female varies from 40 to 60. The moths rest during day-time on the leaves, shoots, etc., and fly in the evening in great masses about the willow trees.

The first generation is, of course, the most injurious to the growth of the osiers.

Spuler says that this species passes the winter in the imago state. I have never found this to be the case in our country. In all three years *Acalla hastiana* hibernated as a pupa.

Last year we observed that the second generation was attacked by a small Hymenopterous parasite belonging to the *Proctotrypidae*. The species has not yet been made known and will be described by one of the Bohemian specialists. The number of hibernating pupae infested with this parasite is from 40 to 60%. The remaining 40%, however, produce such an abundance of offspring as seriously to damage the osiers.

Spraying of experimental willows with some arsenic preparation was successful, a week solution of 3% being used. But spraying must be done at the right time, when the caterpillars are young, i. e. soon after their emergence from the egg. At this time they are not yet protected by leaf-clusters and therefore easily destroyed. In our country the most favourable time is the beginning of June, and for the second generation the beginning of September. If the spraying is done later, the caterpillars are so protected in their leaf-shelters that the results are very doubtful.

It is essential for the basket industry that the osiers be carefully controlled, and I hope that, by spraying at the right moment, we shall be able to restrict the ravages of this insect.

An Account of a Collecting Trip to Patagonia and Southern Chile.

F. W. Edwards, British Museum (Natural History), London.

Summary.

An account was given of an expedition organised at the end of 1926 by the British Museum (Natural History) and the Bacteriological Institute of the National Department of Health, Argentina, for the purpose of collecting insects in the Southern Andes, the collectors being Messrs. F. W. Edwards and R. C. Shannon. The route taken was from Buenos Aires via Patagones and the new Government railway to Bariloche, thence by the lake route to the Chilean coast, returning after a visit to Chiloe Island *via* Concepcion, Santiago and Mendoza; most of the collecting was done in the vicinity of Lake Nahuel Huapi. The main object of the expedition was to obtain collections of insects, especially Diptera, which might throw fresh light on the zoogeography of the south-temperate regions.

A review of the known facts concerning insect distribution in the Antarctic was made by Enderlein in a series of papers published between 1907 and 1912, as a result of which he came to various conclusions regarding previous land-connections. He appears to have started from the assumption that the most certain evidence of such past connections would be found in the lands farthest south, and bases his conclusions on the present scanty insect fauna of antarctic islands, without considering the geological history of the insect groups, or their means of dispersal at the present day. It is, however, most probable that the fauna of these islands was completely exterminated during the pleistocene glaciation and that all the present inhabitants are recent colonists. If that is the case, most of the evidence upon which Enderlein relied was valueless in giving us any clues to the past history of Antarctica. The recent expedition was arranged on the assumption that we should turn for our main supply of evidence on this matter to the regions further to the north, which presumably escaped the severities of the pleistocene ice-age — that is to say to Southern South America ("Archiplata"), New Zealand and Tasmania. Of these the insect fauna of Southern South America was least known, and a district near the northern boundary of the temperate region was therefore chosen for investigation.

As a result of the expedition many additional examples were discovered of resemblances between the insect faunas of temperate South America and New Zealand, and to a less extent those of Tasmania and temperate

Australia. Detailed reports upon the collections of Diptera are now being published by the British Museum, and when these are completed it is hoped to summarise the results in a general survey of the subject of insect distribution in the south-temperate regions. Meanwhile it may be remarked that there is much to support the view that in cretaceous or early tertiary times there was a broad land connection between South America, South-east Australia and New Zealand.

Many or most of the insects common to Archiplata and New Zealand are inhabitants of the *Nothofagus* forest: in fact we may say that the whole insect fauna of this forest shows evidence of a past continuity, and if the forest insect fauna was once continuous, the forest itself must have been also. A different set of insect genera are common to Archiplata and Tasmania; most of those which are not also found in New Zealand are associated with rapid streams, and if, as we may probably assume, the habits of the insects have not changed, this indicates that the land connection was of some considerable elevation.

Among the genera common to Archiplata and Australia, but not occurring in New Zealand or Tasmania (unless perhaps in the eastern half of the latter island) are a number of forms associated especially with dry country, and tending to have a more northerly range both in Chile and in Australia; this might be explained by postulating a fairly broad land connection with a drier and perhaps flatter northern zone as well as a southern forested zone.

Whether the breakdown of the Antarctic connection was due wholly to denudation, variations in the level of the ocean floor, and falling temperature in the south polar region; or whether, as in Wegener's theory, the main factor was the westward drift of the American continent, is hardly a matter for the biologist to decide: but at least it may be said that there is nothing in insect distribution seriously to discountenance the displacement theory. The map given by Wegener of the presumed distribution of land in the Eocene shows the south pole lying in the Pacific to the south of Antarctica, which is broadly connected both with South America and Australia; an arrangement which would be quite in harmony with the conclusions outlined above.

Some Poisonous Arthropods of North and Central America.

W. J. Baerg, University of Arkansas, Fayetteville, Arkansas *).

The tarantulas, various other spiders, scorpions, and centipedes have probably since the early days of man been regarded with fear. Particularly has the tarantula inspired this feeling wherever it occurs, and even at the present time it is difficult to convince anyone anywhere that most or nearly all tarantulas are harmless. In regard to the scorpions, various other spiders, and centipedes, one finds a reputation not so uniformly bad. In certain countries or parts of countries, they are regarded as innocent, or at least not dangerous.

However, the scorpion of Durango, Mexico, has a bad reputation that is well known, not only throughout perhaps the entire Republic of Mexico, but also in a number of our southwestern states. It was with a view of getting some first-hand information about this scorpion and other poisonous arthropods occurring in that part of Mexico, that I went to Mexico in October, two years ago (1926). Besides the City of Durango, where I spent about six weeks, the following localities were visited: Guatimapé, Atotonilco, El Salto, and Tlahualilo.

In this paper I shall try to give a brief account of studies that have been made regarding the effects of the poison of a number of arthropods (including various tarantulas **), scorpions ***), centipedes †), and the Black Widow) occurring in northwest Arkansas, southern New Mexico, the Republic of Panama, and Durango, Mexico. In view of the fact that the scorpion of Durango is, so far as known, the most dangerous of all the poisonous arthropods in the Western Hemisphere, and since I have not heretofore published any account of this species, the major portion of the paper will be devoted to the Durango scorpion.

Tarantulas.

Among the various species that have come under my observation, a large black one, *Sericopelma communis* Cambr., is the only one whose poison produced any decided effect on man. It is very common in the Canal Zone, where it is well known and generally feared.

A white rat bitten on the inside of the left hind leg presented striking reactions. In fifteen minutes it was lying flat on the belly and making

---

*) Research Paper No. 140, Journal Series, University of Arkansas.

**) The tarantulas were determined by Dr. Alexander Petrunkevitch, Yale University, New Haven, Connecticut.

***) The scorpions were determined by Dr. H. E. Ewing, U. S. National Museum, Washinton, D. C.

†) The centipedes were determined by Dr. R. V. Chamberlain, University of Utah, Salt Lake City, Utah.

but feeble attempts to move. The bitten area became considerably swollen and purplish in color. After two hours it showed signs of recovery and in three hours and forty minutes it had practically recovered.

Further tests on this rat showed that immunity against the poison may be developed by three or four doses as introduced by the bite.

On guinea pigs the poison had a more serious effect. The first guinea pig, about full grown, bitten as described for the rat, died in thirty-five minutes. It showed no very striking symptoms, being merely restless and nervous, moving about, licking the injured leg, and washing its face. It died suddenly. Another guinea pig died twenty-three minutes after it was bitten.

To observe the effect of the poison on man, I allowed the tarantula to bite me on the inside of the terminal joint of the left small finger. In view of the serious effects already observed, I took precautions to get a relatively small dose. Only one fang punctured the skin, and it was allowed to remain for about one and one-half seconds. The finger began to feel numb in a few minutes, and in ten minutes the pain was quite severe. The small finger developed considerable swelling and this gradually spread over the entire hand, but did not go beyond the wrist. Two hours after the bite had taken place, I put the hand in hot water for thirty minutes. This ended the pain almost completely, most of the swelling disappeared, but a lame feeling in the small and third fingers remained for several days.

Another tarantula, *Psalmopoeus pulcher* Petrunk., in the Canal Zone, is a very handsome species covered with long and dense grayish buff colored hairs. Only one male was taken and this was induced to bite experimental animals and man as already described. Aside from evidence of pain, no appreciable effect of the poison could be observed.

From Honduras a medium-sized, blackish, and rather hairy tarantula was brought to Fayetteville, Arkansas, in a shipment of bananas. Owing to the fact that it is apparently an immature specimen, it has not been determined further than to the genus *Eurypelma.* Since I was away at the time, my student assistants made some tests of the poison on white rats. The rats showed some response, but it was no more than slight illness, and this passed away in an hour and a half.

In the Republic of Mexico, the tarantulas are well represented. Seven or eight species are on exhibit in the Museum of Natural History of Mexico City, and according to Moises Herrera, eleven species are known to occur in Mexico. They are generally regarded as deadly or dangerous.

The common people have named the tarantula "hierba" and "mata-caballo", meaning weed, or horse-killer. This is based on the belief that the tarantula on biting a horse's foot will cause a disease called hierba (or weed), which nearly always results in death.

Near Tlahualilo, a large ranch located in the northern part of the well known Laguna dsitrict, the tarantula *Dugesiella crinita* Pocock is fairly abundant. A colony located near the ranch headquarters covered many acres, and must have included several hundred spiders. *Dugesiella crinita* attains a respectable size, that is about half again as large as our native tarantula, *Eurypelma californica.*

This Mexican tarantula lives in holes from eight to ten inches deep. Of its habits nothing could be learned except that mating takes place in November. One adult female, the largest I was able to get, was brought back alive for further observation. Its feeding capacity is of interest. From six to eight large grasshoppers *(Melanoplus differentialis,* or *Schistocera americana)* are taken in a week. This is about five times as much as the adults of our species will accept in that time.

The effect of the bite of this species is not difficult to determine, for it is easily induced to attack, and the powerful fangs readily penetrate even the hide of full grown guinea pigs. Several tests on guinea pigs, as well as on myself, failed to produce any noticeable effects except such as are felt after a pin prick. One of the tests on myself was accidental and in this the fangs both penetrated rather deeply into the terminal joint of the left middle finger. The pain resulting directly lasted for no longer than about thirty minutes. For purposes of comparison and verification, a distilled water extract of the glands was made and injected into a guinea pig. The result was the same as already described.

D. crinita occurs also in the neighborhood of the city of Durango.

Another tarantula found in this locality is *Metriopelma breyeri* Becker. On account of the lateness of the season, only one specimen was secured, and this was somewhat young for purposes of experimentation.

Owing to the fact that but one specimen was available, the test on rats was omitted. On myself it produced a sharp pain that lasted about half an hour.

In the southwestern United States, Arkansas and westward, there is a tarantula, *Eurypelma californica* Ausserer, of moderate size that seems to have a fairly wide distribution. In Arkansas it is apparently the only one present. It occurs commonly in Texas, and in southern New Mexico I was unable to find any other than this species. A study of this tarantula was begun about ten years ago and is still being continued. Several papers relating to the effects of its poison, its habits of feeding, reproduction, and regeneration, have been published.

This tarantula has been credited with prodigious power in jumping (ten to twenty-five feet), and it is everywhere within its range or where its reputation has spread, feared greatly on account of its alleged poisonous nature. The high degree of fear exhibited towards this innocent creature is well illustrated in a story that recently appeared in one of our daily newspapers. This story was briefly as follows. A man driving along in a Ford touring car suddenly realized that a huge tarantula had somehow gotten into the car. Without attempting to stop the car, he leaped out over the door. The car ran over an embankment and was wrecked, but the man considered himself lucky to be alive and unharmed.

Many tests have been made with the poison of this tarantula. On white rats and guinea pigs both the bite and injections have been employed. The injections were made by grinding up both poison glands in distilled water, and also in physiological salt solution. On guinea pigs no serious effects have ever been observed. On white rats, one to two months old, four deaths have been observed. The bite and the injection proved equally fatal. As a rule the bite of this tarantula is not fatal

to rats, but nevertheless it produces fairly definite symptoms. At first the rat runs about excitedly, and in a jumping and jerky manner. Then it becomes more quiet and appears to have considerable pain in the wounded leg. For much of the time the eyes are closed. In about four or five hours the rat shows evidence of recovery and in another hour it is normal.

On myself I tried the bite of this tarantula twice, and subsequently I have been bitten by accident. The relatively dull fangs produce a pain that may be compared to that made by a pin prick. It lasts for only fifteen to thirty minutes and is not accompanied by any inflammation or swelling.

One of the funnel-web tarantulas, *Evagrus pragmaticus* Chamberlain is commonly found under stones in the neighborhood of the city of Durango, Mexico, and farther west towards El Salto. It apparently prefers altitudes near 6,000 feet and higher. It is a small spider, about three-fourths of an inch in length, and of a uniform velvety black color.

The effect of the bite was tried first on a white rat, about two months old; as in previous tests, the rat was bitten on the inside of the left hind leg. The spider, after a little coaxing, bit well and held on tenaciously. For more than an hour, I observed no apparent symptoms. When an hour and fifteen minutes had elapsed, the leg was decidedly swollen, and the skin was purplish in color. Surrounding the punctures was a bloody patch of an area of a square centimeter. The blood seemed to be oozing through the skin, and formed a small pool. It did not seem to trouble the rat, for it continued to use this leg as much as the other. Five hours and fifteen minutes later the oozing out of the blood had stopped and on the morning of the following day the leg appeared very nearly normal.

Another test of this species was made on a guinea pig. Fifteen minutes after the bite had taken place, an accumulation of blood under the skin near the puncture was clearly visible. In thirty minutes after the bite, the blood was oozing through the skin and a pool of blood similar to that observed on the rat appeared. Five hours later the blood began to coagulate and form a scab. On the following morning the leg appeared quite normal.

In trying the funnel-web tarantula on myself, I took but a small dose of the poison, and as a result know very little of the effects on man. There was a noticeable sharp pain, that lasted for about an hour. Several blood capillaries near the bite (on the inside of the left small finger) enlarged so as to become somewhat conspicuous. There was no gathering of blood on the surface.

Scorpions.

The order Scorpionida is well represented in Mexico. Moisés Herrera in the Guia lists six species. In the Museum of Natural History in Mexico City, fifteen species are represented. In view of the fact that literature on this subject is somewhat scattered and difficult to secure, a considerable portion of the paper has been devoted to a discussion of the work of various investigators. In addition, an attempt

has been made to give a fairly complete list of references. The scorpions are naturally well known and have long attracted a good deal of attention.

The Mexican legend of the scorpion (Moisés Herrera) explaining the origin of this arachnid is briefly as follows: Penitent Yappan, desiring to become pleasing to the gods, separated from his wife, Tlahuitzin, and retired to a solitary mountain where he made a solemn vow of chastity. However, he was unable to withstand the charms of Tlazolteotl, the Goddess of Impure Love. After breaking his vow he was punished by having his head cut off and being transformed into a scorpion. His wife was taken to the same place, likewise beheaded, and changed to a scorpion. It is significant to note that the dark and ashy colored (harmless) species are said to have all come from Yappan, and the reddish and fiery kinds have all come from his wife.

The Aztecs called the scorpion Colotl, and in some ancient museums it is represented with spiders, centipedes, and rats accompanying the Sun God, who is also the Lord of the Underworld. Although generally regarded as repugnant, some natives after removing the poison sting from scorpions will use them for food.

In the Gazeta de México, one of the early Mexican newspapers, for December 29, 1784, is an account of a shipment of snake weed from Tehuantepec, that has been sent to Durango to be used as an antidote for the poison of the scorpion and other animals. It is given as a powder mixed with cold water, and is a cure also for hydrophobia, apoplexy, and epilepsy. Incidentally, this snake weed is a stimulant and is even now used by the Indian long distance runners.

A later issue of the Gazeta (April 19, 1785), reports that the Municipal Government of Durango is offering a bounty of one-half real (6¼ cents) for every half dozen live scorpions brought before the Prosecuting Attorney. The bounty proved attractive, for in the two months, April and May of that year, 19,300 scorpions were brought in. The Gazeta for October 17, 1787, reports that to date (from April 19, 1785) bounty has been paid for 506,644 scorpions. It is hoped that such a vigorous campaign of extermination will soon reduce the population of scorpions very considerably.

Cavaroz, writing nearly a hundred years later, 1865, says that the Municipality of Durango is paying 15 cents a dozen for scorpions, that the children hunt them, and destroy from 80,000 to 100,000 during the hot season, April, May and June.

Since 1785 this bounty has been paid in varying amounts for all, or nearly all, of these 143 years that have elapsed. It is still being continued, but apparently it has not materially reduced the scorpion population, for in 1925 the boys collecting scorpions (popularly known as alacranéros) brought in 116,000 specimens. In 1926, they gathered about 20,000 specimens. Last year (1927) the scorpions seemed unusually scarce; only 8,000 were collected. The bounty paid was 5 cents for females and 2½ cents for males *).

*) In 1928, May 1 to July 31, 12,941 scorpions were collected in and near the city of Durango. The bounty paid was 2½ cents for the females and 2 cents for the males.

An early record of an attempt to devise more effective methods of extermination appears in this Gazeta, in the issue already mentioned above (April 19, 1785). It says the Governor of the State of Durango is reported as offering from his salary the sum of 500 pesos to be paid to the person who will devise an efficient method by which the scorpion may be exterminated. The governor was not kept waiting for any length of time. In the Gazeta for July 12, of the same year, the method is announced and discussed at considerable length.

This method, or secret as it is called in the paper, is as follows: "Take one part of the shavings of hartshorn, another equal part of ash wood, and another of sulphur, and mix them. Place in a brazier with a well burning fire, put one in each room of the house, and on each one throw some of the mixture in amounts sufficient to fill the house with smoke, and the scorpions will die."

Recently Dr. A. L. Herrera has recommended fumigation with hydrocyanic acid gas. At least one attempt to destroy scorpions by this method has been made in Durango; apparently the results were not encouraging. Experiments at the Instituto de Oswaldo Cruz, Brazil, have apparently not produced anything very promising along the line of fumigation or the use of insecticides. Dr. Felipe Brachetti says: "The powder of chrysanthemum will drive scorpions away, or even kill them, and so does creoline." He recommends a dilute solution of creoline to be sprinkled on the floors and on the flower beds about the house. The so-called Durango scorpion is said to occur, besides in this state, also in the States of Morelos, Tepic, Michoacan, Zacatecas, Sonora, Sinaloa, Guerrero, and in the lower Gila region of Arizona. The popular name, alacrán, is the same as is generally used for all scorpions in Mexico. The scientific name has changed many times, and probably will continue to change until someone can make an exhaustive taxonomic study of the scorpions of Mexico. Latreille called it *Centrurus gracilis.* It is also known as *C. exilicauda* Wood, *Ischnurus mexicanus* Villada, *Centrurus mexicanus* Jojutla, *Centruroides elegans* (Herrera), and *Centruroides obscurus* (Avendano). Dr. Ewing of the National Museum, who has identified all my scorpions, calls it *Centruroides suffusus* Pocock. It resembles *Centruroides vittatus,* the species common in Arkansas, Oklahoma, and other southwestern states, so closely that Pocock has considered it a subspecies of *vittatus.*

Even the old statistics on the death rate due to the scorpion, although they may seem unreliable, indicate clearly that the Durango scorpion presents a very important problem to that community. Cavaroz gives the earliest death rate that I have seen. The issue of the Gazeta of April 19, 1785, says that many grown persons, and all children not over twelve die (when stung). Cavaroz says that in a city such as Durango, of 15,000 or 16,000 people, 200 persons are annually killed by the scorpions. These figures are probably an exaggeration, even for those days when the practice of medicine was far below the efficiency it has now acquired.

According to more recent figures by Dr. H. V. Jackson, the Durango scorpion caused 51 deaths in 1907, 53 in 1908, and 53 in 1909

Since the city has a population of between 40,000 and 50,000, this is a death rate of one in a thousand. During the period from 1890 to 1926, a period of 36 years, there have been 1608 deaths, giving an average annual mortality of 44.6. For 1927, incomplete records show over 40 deaths *). These deaths are largely in the hot season, April to July inclusive. The majority of victims are children from one to seven years of age. Although adults, as a rule, do not die from the effects of the poison, there are notable exceptions. Dr. Jackson reports a case of a man twenty years old who died forty minutes after being stung. Very old persons are said to be very susceptible to the effects of the poison, but I have not been able to obtain any figures. Dr. Felipe Brachetti says that pregnant women are not affected by the poison. There is a popular belief that bad or disreputable characters are not only immune from the effects of the poison, but that a scorpion on stinging them is killed itself. One of the generals in Durango assured me that he himself had demonstrated this to be a fact. There is also a well established belief that the scorpions are much more deadly during the hot season, April to July, than at other times of the year.

How seriously the people of Durango regard the danger of the scorpion may be seen in some of the measures they employ to get rid of it. Thus, about 3½ years ago there was a procession of 1,000 children, all carrying candles, who marched into the cathedral and implored God and the Saints to do away with the dreadful menace.

The chemical and other properties of the poison have been studied by Jackson, Kubota and others. It is a transparent liquid; when agitated it produces a froth; it is acid in reaction; when evaporated, it leaves scaly flakes of dark yellow color, which are soluble in water, normal saline, glycerine, and dilute alcohol. Pure alcohol, iodine, ether, ammonia, and tannin precipitate the poison. It is also precipitated by lead nitrate and silver nitrate. Heating to 100° C for thirty minutes destroys the poison. The toxic principle is in the nature of a tox-albumin. It has a haemolytic action on nucleated as well as non-nucleated blood corpuscles. In rats and guinea pigs, death seems to be due to paralysis of the respiratory system; in frogs, to a central and peripheral paralysis (Kubota).

The symptoms on man have been fully described by Santa Maria, Jackson, Jesus Sanchez, Brachetti and others. Immediately following the sharp pain produced by the sting is a feeling of numbness or drowsiness, then there is an itching sensation in the nose, mouth, and throat that makes the victim distort the face, rub nose and mouth, and sneeze. There is at first an excessive production of saliva; this and a curious feeling that is described as the sensation of a ball of hair in the throat, induce the victim to swallow as rapidly as possible. The tongue is sluggish, so that communication is often by signs. The muscles of the lower jaw are contracted so that it is difficult, or impossible, to give medicine through the mouth. There is a disorder of movements in arms and legs. The temperature rises rapidly to 104 or 104.8° F,

*) In 1928 seventeen deaths were recorded.

the salivary secretion now diminishes and there is a scarcity of urine *). The senses of touch and sight are affected, objects appear large on touching them, hair feels rigid, face feels bulky, a veil seems to be interposed between the eyes and various objects, strong light is unpleasant to patients. Luminous objects, such as a candle, are surrounded by a red circle. Frequently there is a pronounced strabismus. There may be a hemorrhage of the stomach, intestine, and lungs. The convulsions come in waves and increase in severity for an hour and a half to two hours, or in severe cases until a fatal result. When the case ends in death, respiration stops a full minute before the pulse ceases to beat. When the patient survives for three hours he is usually considered out of danger; yet death may occur six to eight hours after the patient was stung. It is then probably due to nervous exhaustion following the long periods of convulsions.

Treatment **) for scorpion stings among the peons is somewhat as follows. A ligature is applied if feasible, the puncture is cauterized with a live coal or a cigarette, and ammonia may be applied locally. A small piece of gum made from the plant called Guajiote is applied on the punctures and held there with a bandage. The various drugs and other substances used internally are numerous and of great variety. One that Dr. Brachetti describes as very nasty is for the person stung to eat his own excrement, or to drink an infusion of the excrement. Alcohol, or alcohol in which a number of scorpions have been kept for a long time, is commonly given. In ancient times scorpion oil was used. Mezcal is very generally used. A very popular remedy is turpentine, a spoonful on a lump of sugar. It is said to modify the symptoms of poisoning quite appreciably. An infusion of rosemary, tincture of purple sweet potato, and extract of *Aristolochia pardina* Duch. (an aromatic woody plant) are commonly used. The stems of the latter are cooked in water, or soaked in alcohol. It is a sweat producer.

Numerous drugs are used or recommended. Chloral hydrate and ammonium bromide, together made into tablets, are very commonly used. Pilocarpine, morphine, and hiocina, cactina, and potassium iodide and other sedatives are recommended.

Calcium hypochlorite, used in Russia against the poison of *Latrodectus erebus,* was recommended by Santa Maria in 1893, but so far as I know it has not been seriously tried in Mexico.

---

*) The African scorpion, *Buthus quinquestriatus,* produces similar symptoms. In Gabón, Souchard (The River Gabón and Its Diseases, Thesis of Montpelier, 1864) has seen in practice a species of judgment of God which consists in having an accused person bitten by a scorpion. If the patient emits urine during the first period of the poison, it is a certain sign of his innocence. — Translated from Jesús Sánchez, Med. Zool.

**) Dr. Brachetti, in an account of the case of a woman twenty-seven years old, after a description of her symptoms, gives a good picture of the use of home remedies: "She had placed immediately a cord on the wrist, tightly twisted by a man to such a degree as to make the hand become dead by the complete suspension of the capillary circulation in that region, and also in spite of the fact that she had cauterized with a cigarette the place of the bite, and had taken two or three spoonfuls of bromochloral and pilocarpin, which is commonly used in these cases, also two cups of mezcal, a remedy which is very much used among the people."

Chloroform is, according to Dr. H. V. Jackson, the remedy par excellence. Dr. Santa Maria first used this in 1859. He found that eight to ten inhalations would render the patient quiet and usually put him to sleep. This condition is kept up by a few inhalations at such intervals as necessary to assist the patient until he recovers. Dr. Jackson gave chloroform in this manner, and maintained this state of anaesthesia for three hours. In 1893, Dr. Santa Maria reported that during the twenty-five years that had elapsed since he first tried chloroform, he had treated three hundred cases with very gratifying results. To modify or eliminate the poison, tincture of iodine well diluted with water is given at once. Profuse perspiration is highly essential and this in children is brought about by hot water baths, in adults by injection of pilocarpine.

The Use of Serum. — Following Calmette's announcement that the toxic principles of all different origins (including snakes and scorpions) are the same, and suggesting the use of his anti-cobra serum as a remedy for scorpion poisoning, this was tried by Vergara Lope, Gomez Palacio and H. V. Jackson, but failed to produce the desired results.

Vergara Lope prepared an extract of scorpions, using 80 scorpions without poison in 160 cc. of distilled water. This was tried on various experimental animals and showed some promise. According to Ocaranza it was used on man by a Dr. Carillo in the State of Morelos, who injected 5 cc. of the extract, and prompt relief appeared in two to five minutes.

Dr. Jackson attempted to make a serum by immunizing a male goat. When used on rabbits it showed promise, but the work remained unfinished. The most recent attempt is by the Drs. Carlos de la Pena and Isauro Venzor of Durango, Mexico. In the making of the serum they used a horse and followed the method devised by Dr. Vital Brazil of the Instituto de Butantan, Brazil. On guinea pigs this serum when mixed with the poison extract of scorpions gave very good results *). Dr. Brachetti reported last year that he had tried this serum on man with gratifying results.

That some kinds of scorpions resemble each other so closely that even students of the taxonomy of this group meet with serious difficulties, is perhaps well known. This fact is responsible for numerous contradictions and much confusion in the literature dealing with the Durango scorpion. In the localities that I visited, six species were taken, and besides several kinds that could not definitely be determined. Not only do various species resemble each other a good deal, but certain species, notably *C. suffusus*, the notorious one, vary a good deal.

In my studies, the principal aim was to find as many as possible of the different species occurring in Durango, to determine which of these are dangerously poisonous to man, and to determine the symptoms of poisoning caused by the various species of scorpions.

---

*) In 1928 this serum was used in numerous cases, according to a letter from Dr. Carlos Leon de la Pena, and gave the desired results in all but one case. This was a child that was treated a "long time" after it had been stung and was already seriously ill.

In making the tests of the effects of the poison, I have, as in previous studies, induced the scorpion to sting white rats and guinea pigs on the inside of the left hind leg. In some instances additional tests were made with an extract *) made by grinding up the poison glands in one cc. of distilled water. The extract was injected subcutaneously in the left hind leg.

Diplocentrus keyserlingi Karsch, taken in the neighborhood of Durango, is a dark colored and large handed species. The hands and fingers are blackish brown, the carapace and preabdomen are a greenish dark brown, the postabdomen and the legs are brownish, lighter than the preceding parts. It attains a length of 6 cm in the male and 5.5 cm in the female. On white rats, about seven weeks old, the sting produced a slight swelling; no other effect was observed. On myself, although stung by several individuals, there was no effect besides the slight pain caused by the entering of the sting.

Diplocentrus whitei Gerv., taken at Tlahualilo, resembles *D. keyserlingi.* The largest specimen that was taken has a length of 7 cm. Owing to a shortage of experimental animals, this species was not tried on rats or guinea pigs. Several punctures from two scorpions failed to produce any appreciable effect on me, except the slight pain of the puncture that lasts for a few minutes. These scorpions seem to use the poison rather freely, but it appears to be entirely harmless to man.

Anuroctonus mexicanus is a new species that has just been described by Dr. Ewing. It occurs commonly in the neighborhood of Durango. The largest specimen that I have has a length of 5.7 cm. The large hands and general appearance are somewhat like the *Diplocentrus* species described above, except that the pedipalps are dark brown in the new species and blackish in *Diplocentrus.*

My notes on the poison tests of this species are somewhat confused, hence no clear evidence can be presented. The observations that were made permit me to say that the poison has no more effect on man than *Diplocentrus keyserlingi.*

Vejovis mexicanus Koch was taken at Guatimapé, and other species of Vejovidae that have not been definitely determined were taken at Tlahualilo and Durango. To the casual observer these resemble the various species of *Centruroides* in general color pattern and appearance, except that the postabdomen is somewhat strikingly stout in these Vejovidae.

---

*) Dr. Vital Brázil of the Instituto de Butantan has indicated a strong preference for this method over that of the direct bite or sting, for the reason that in the former the dosage of poison is definitely known, while in the latter it is somewhat indefinite. There is no very good ground for such an assumption. The quantity of poison varies with the relative fullness of the glands. That this varies considerably can easily be seen by extracting the glands from a few spiders. Furthermore, even if the glands are full the toxic principle may be more dilute in one spider than in another. A more significant point is that, for instance, the poison of *Latrodectus mactans* when prepared in the form of an extract in physiological salt solution and injected, does not, according to my observations, produce any serious symptoms of poisoning in white rats; while the bite does produce very marked symptoms. This observation has been made also (independently) by Dr. Emil Bogen of Los Angeles. Finally, it may be argued that the effect of the bite or sting of the various poisonous arthropods is of more immediate interest than the effect of an injected extract.

On white rats and guinea pigs the sting did not produce any noticeable results. On myself there was a rather sharp pain, but this disappeared in a few minutes.

Centruroides ornatus Pocock was taken at Durango and at Atotonilco. The largest of my specimens is 5 cm in length. Dr. Ewing says that *C. ornatus* is almost indistinguishable from *C. suffusus*. This is very true in alcoholic or dried specimens. In the live specimens, I had very little trouble recognizing *C. ornatus*, because it has a good deal of red and some orange color on the pedipalps. There is no trace of this in *C. suffusus*, so far as I know; however, the brown fingers on *C. suffusus* may lead to a confusion between the two. Although this distinguishing character apparently served well, an examination of a larger series may prove that it is not reliable.

A white rat after being stung by *C. ornatus* developed a marked degree of illness in about thirty minutes, and favored the leg in walking. This lasted for only about fifteen minutes. Another test was made by injecting an extract of the glands in distilled water. The injection was made subcutaneously on the inside of the left hind leg. The rat responded very much as the preceding one, except that the leg swelled considerably, and around the puncture there appeared a purplish discoloration.

Having heard repeatedly that the poisonous scorpion is most dangerous during the hot season, it seemed possible that this was the one for which I had been searching. However, additional tests gave no more than the mild symptoms already described.

On myself the sting produced a sharp pain at once and this remained steady for about fifteen minutes. There was also some perceptible swelling. In an hour and a half both pain and swelling had practically disappeared.

Centruroides suffusus Pocock, as already stated, occurs in various states in the western part of Mexico and also in the southern part of Arizona. However, in no locality is it so numerous as in that of the City of Durango, and nowhere has it caused as many deaths as in this locality. Unfortunate as it is, there is probably nothing of Durango, not even the famous Iron Mountain, that is so well and so widely known as the reputation of the Durango scorpion.

The average length of a full grown female is 6 cm, that of a male a little more, about 6.2 cm. In life the adult female is recognized by the brown fingers. This character apparently does not appear in the males, nor in the immature forms. The alcoholic specimens, as already pointed out, are almost indistinguishable from *C. ornatus*, and as previously stated, they resemble *C. vittatus* so closely that Pocock considered *C. suffusus* a subspecies of *C. vittatus*.

In the choice of its habitat or shelter, *C. suffusus* presents a strong preference for ruins, and here I found it almost exclusively under adobe bricks, very rarely under stones. It is known to occur commonly in houses and other buildings. Although I spent many days on the hills near the city of Durango, only two adult females were secured. When searching in the ruins of the San Francisco cathedral, a dozen full grown females were found in about one hour. And what seemed quite as strange, in these ruins no other kinds of scorpions were found, although I searched

thoroughly for several days. It seems that of all the different species of scorpions, this, the only dangerous one, has developed a preference for human dwellings, other buildings, and ruins.

Since the poisonous species is found usually under or between adobe bricks, many people believe that it feeds on dirt or clay and as a result of this is poisonous. Another curious belief is that the young, which the female carries on her back for several weeks, devour the mother before they leave. There is a common saying, often applied to the boy who spends too much of his father's money: "As ungrateful as the child of a scorpion" (Pareces hijo de alacrán). According to reliable observers, the female scorpion commonly dies before the young leave her, and they devour of her whatever is suitable before they search for food elsewhere. This is very different from the habits of the young in *C. vittatus*, but the evidence seems quite reliable.

The first test with an adult brown-fingered female left no doubt that the poisonous kind had been located. A white rat, about two months old, was stung several times. In eight minutes the rat was much agitated, rubbed its nose frequently, and favored the leg strongly in walking. In fifteen minutes after being stung, convulsions set in, these rapidly became stronger so that the rat would roll over backwards, and sideways, jump up against the top of the screen cage, and often squeal as it jumped or jerked. It would try to sit still now and then, when it could be observed panting very rapidly; but these intervals lasted for no longer than a second. This continued for an hour from the time it was stung. Then the convulsions became gradually milder, the periods of rest grew longer, and four hours later the convulsions ceased. On the following day the rat appeared entirely normal.

A test of the sting on a full grown guinea pig *) gave the following results. Six minutes after being stung, the guinea pig began chewing vigorously, ten minutes later it sneezed, ten minutes later it began sneezing more frequently, chewing and vomiting. Convulsions began nearly thirty minutes later, and bloody urine appeared. The leg was but slightly swollen. The guinea pig became extremely ill, and very weak from the convulsions. Nearly seven hours after it was stung it began slowly to improve. On the following day it appeared to be quite normal.

Another full grown guinea pig that was stung several times began sneezing two minutes later, and in twenty minutes it had severe convulsions. It died forty-three minutes after it was stung.

An extract made of the glands of one scorpion in 1 cc. of distilled water was injected subcutaneously in the left hind leg of a full grown guinea pig. Sneezing began in 14 minutes, convulsions in 20 minutes, and death set in after 57 minutes.

Another test with the extract of the glands of one scorpion was made on a white rat, about two months old. In five minutes the rat was in severe pain, and having convulsions; in twenty-five minutes it was dead.

---

*) The guinea pigs used in these tests were supplied gratis by Dr. Carlos Leon de la Pena of Durango.

The rat that was used in the first test with this scorpion was subjected to further tests in order to learn how rapidly immunity would develop. The second test was made three days after the first. Although the rat was stung vigorously several times, it did not develop any convulsions. It looked very sick and chewed rapidly. One hour and thirty minutes after it was stung, it took food and appeared entirely well. A third test made two days later gave but very feeble symptoms. The rat looked a bit sick, but did not even favor the leg in walking.

Considering the high toxicity and very rapid action of the poison, the development of appreciable immunity requires a remarkably short time.

Dr. Arthur Locke and Dr. G. M. Crowe, of the Research Laboratory of St. Luke's Hospital of Chicago, very kindly offered to make a post mortem examination of a victim of the Durango scorpion. A guinea pig, about full grown, was injected with an extract made of the glands of a well-dried scorpion in two cc. of physiological salt solution. The guinea pig presented the symptoms already described, with the difference that they came on more slowly. The pig died one hour after the injection.

The examination showed the stomach blown up with air that had been swallowed, heart and lungs somewhat congested with blood. The poison, as shown by the symptoms, is clearly a neurotoxin.

Owing to the fact that the results of the poison in man are well known, I contented myself with a very small dose. This resulted in a sharp pain that lasted for about an hour, and a decided sensitiveness that lasted for more than six hours.

A problem that is inviting immediate attention might perhaps be pointed out. When I had gradually gathered an assortment of all the scorpions common in and around Durango and had tested the poison of every kind, there seemed to be no difficulty in recognizing each kind, and the poisonous species was easily distinguished from the rest. However, when Dr. Ewing had determined the alcoholic specimens he found that at least two kinds that I considered harmless after repeated trials on rats, guinea pigs, and myself, belonged to the same species as the one that had been found dangerously poisonous. There is some indication that the immature forms of *C. suffusus* are harmless, and possibly the males are less dangerous than the females. This and other matters I hope to investigate later.

Among other scorpions that have been studied are two species from the Canal Zone. *Centruroides margaritatus* Gerv. is a fairly large scorpion, up to 95 mm in length, and probably larger. It is apparently the more common of the two species.

The sting when tried on white rats and white mice did not produce any appreciable symptoms. Reliable observers have reported that on man the sting causes in some individuals a numb feeling or tingling extending practically all over the body, and a lameness particularly noticeable in the tongue. On myself the sting did not produce any such symptoms. There was a fairly sharp pain lasting for thirty minutes, and a feeling of warmth or a glow that I had not observed from other scorpions.

The other scorpion more or less commonly occurring in the Canal Zone is blackish in color and has strikingly large pedipalps. These are

its weapon of defense and offense. The postabdomen is slender and weak and the sting is employed only when the pedipalps cannot be used.

The poison apparently has not the slightest effect on white rats. On myself I could not observe anything beyond a very slight pain resulting from the puncture, and this disappeared in a few minutes.

In southern New Mexico (from Mesilla Park to Deming), there is but one scorpion, *Vejovis spinigerus* Wood, that is at all common. Its poison had no appreciable effect on white rats, and on myself it caused only a slight pain which disappeared in less than a half hour.

In Arkansas there is likewise but one species, *Centruroides vittatus* Say. It is commonly found in many parts of the state, and has been reported from several southern and southwestern states. It is slightly larger than the New Mexican species, measuring about 55 mm in length.

The effect of its poison on man has been observed on various occasions, and may be compared to that of a wasp. Around the puncture a small white disc usually forms in a short time, and the pain is somewhat severe for fifteen to thirty minutes.

Centipedes.

The following centipedes have been studied in regard to the effect of their poison: *Lithobius mordax* Koch, *Theatops spinicaudus* Wood, *Scolopendra heros* Gir., from northwest Arkansas; *Scolopendra polymorpha* Wood from Mesilla Park, New Mexico, and Durango, Mexico; *Scolopendra viridis* Say from El Salto, Mexico; and *Scolopendra sumichrasti* Saussure from the Canal Zone.

In various parts of Mexico, *Scolopendra polymorpha* is fairly common. In the State of Durango it was taken in the following localities: Durango, Atotonilco, Guatimapé and Tlahualilo. The only other species of centipede that I was able to find in Durango was *Scolopendra viridis*. It was taken at El Salto, which has an altitude of 8000 feet, about 2000 feet higher than the city of Durango.

It is somewhat surprising that in Mexico the centipedes are apparently not regarded as dangerous as they are in the United States. Only the large species, according to Moisés Herrera, are dreaded.

The poison of all these centipedes has apparently no appreciable effect on white rats. On man the bite of the larger species such as *Scolopendra heros* and *S. polymorpha* is quite painful; however, this sensation lasts for only a few minutes. Later there remains for several hours a feeling that suggests a fine splinter in a wound. This sensation is very marked whenever the bitten area is gently pressed.

The Black Widow.

The Black Widow, *Latrodectus mactans* Fabr., and its near relatives are well distributed over the torrid zone, and a large portion of both temperate zones. I have found it frequently in various parts of Arkansas, New Mexico and Durango, Mexico.

In the neighborhood of the City of Durango, it is very common. It is fairly well known by the popular name Arana capulina, apparently because of its black color and a spherical shape resembling a cherry. In

general it is not regarded as dangerous. However, an old reference from Padre Sahagún says in regard to the effect of the poison: "The sting causes fatigue for three or four days, though it does not kill. The extract of these spiders is very medicinal for many infirmities." Dr. Carlos Bustamente says: "Their sting is deadly, cured with alkali, and the Indians (cure it) with a bean of the same shape and size as the spider, half black and half white, which they grind up and drink as a gruel."

Among the several specimens that were taken near Durango there were two in which the red hour glass figure was entirely lacking. No tests were made with this species in Mexico.

In Arkansas the Black Widow is most commonly found under stones and similar retreats wherever the ground is moderately dry. During a dry season the spiders, apparently in search for moisture, find shelter under stones in dry creek beds. At such a time they are also found in the housing of water meters and basements of houses.

Formerly many arachnologists regarded the Black Widow as no more dangerous than other spiders; while medical entomologists were generally agreed that the bite of this species and others of the genus *Latrodectus* produced more or less serious consequences. The evidence, however, was circumstantial. In practically all cases the spider was not reliably identified, and as a rule the symptoms had for their basis a very considerable degree of fear, and often improper treatment.

In an attempt to obtain a reliable record of the effects of the bite of this spider, a number of tests were undertaken. The extremely shy and timid nature of the spider renders attempts to make it bite exceedingly difficult. After many futile attempts it was learned that spiders which had not been fed for two or three days were more readily induced to bite than the ones that had recently fed. Obviously the manner of holding the spider, which one learns only after a number of attempts, and the most effective way of teasing it with a camel's hair brush help in bringing about the desired results.

For preliminary tests, white rats, about four weeks old, were used. These were prepared by clipping off the hairs on the inside of the left hind leg. Following the bite, in which the fangs were allowed to remain in the wound for several seconds, the rats soon presented distinct symptoms of illness. They humped up, turning the head underneath till the face touched the floor of the cage. From time to time they would jerk forwards as if in convulsions. The eyes were usually closed and the rats were not easily aroused. When walking they were very unsteady and stumbled frequently. These effects lasted from six to ten hours.

A considerable number of tests were made on rats. For purposes of comparison, the poison was injected in the form of an extract. This was made by removing the glands and grinding them up in distilled water, for some tests; and in physiological salt solution in others. Altogether at least twelve tests were made. In the rats that had been injected the symptoms were very decidedly milder than in the ones that had been bitten. In these they varied somewhat, naturally, because the dose of poison is not always the same; but considering the reluctance with

which some of the spiders would bite, the results were remarkably uniform.

A somewhat surprising fact is that in no case did the bite produce death in the young white rats. Several rats were bitten successively four times, with several days intervening between the various doses, and these showed that fairly complete immunity may be developed by three large doses of the poison (about as much as one spider is able or willing to give when biting).

In order to determine the effects of the poison on man, I induced the spider to bite me on the inside of the third finger. After much coaxing, it bit, but very feebly, so that the sensation produced by the fangs piercing the skin was barely felt. Later this spot was covered with profuse perspiration, but no other symptoms were observed.

A day later another attempt was made and this was entirely successful. Inasmuch as I expected only mild symptoms, judging by the effect of the poison on white rats; I allowed the fangs to remain in the punctures for about five seconds. The results were all that one could wish for.

Soon after the bite took place (8 : 25 a. m.) a sharp pain developed. and small white discs appeared around the punctures. Soon the third finger became very red and some swelling developed. In about fifteen minutes there was an aching pain in the muscles of the left shoulder; in a half hour the arm seemed lame and the aching was more marked.

By 10 : 25 the pain in the left hand was very severe, a sharp burning sensation, and the aching in the arm had extended to the chest. At 12 : 20 I had seen a doctor and on his advice went to bed. The pain was now severe in the hips, the chest felt cramped, breathing and speech were forced and irregular.

In view of the rapidly developing symptoms, it seemed best to go to the hospital. This I did at 5 : 30 in the evening, and remained there for three days. During the first night I could not sleep because of the severe pain; on the second night I was much troubled with a sort of delirium that produced weird and disagreeable dreaming.

Attempts to bring relief by a frequently renewed application of KMNO4 solution, and placing the hand in an electric oven, failed completely. Hot baths, prolonged considerably and taken several times a day, gave each time decided relief, which was in part permanent. That is to say, the hot water not only stopped the pain for the duration of the bath, but it appreciably lessened the pain that returned later.

From the hospital record, I learned that a slight fever, 1—2 degrees, was present in the afternoon and evening of the days that I spent in the hospital. Later I took readings of my temperature and found that it fluctuated from 96 or 97 to 99 or 99½. This condition lasted for several weeks.

In considering these symptoms, it must be remembered that they were caused by an abnormally large dose. However, the dose was certainly not greater than used on the white rats. The tests show conclusively that man is much more susceptible to the poison than are white rats. In man the poison, even in an average dose, such as a spider would inject in a second or two, the symptoms are likely to be quite disagree-

able. Unless the bite is on a small child, in a particularly sensitive area, for instance the neck, the results are not likely to be dangerous.

Summary.

Among the tarantulas that have been studied, one species from the United States, two species from Mexico, one species from Honduras, and two species from the Canal Zone, only one, a large black species from Panama, *Sericopelma communis*, has a poison that has an appreciable effect on man. Although decidedly painful, the bite of this tarantula is probably not dangerous.

Of the various scorpions that have been studied, one species from Northwest Arkansas, one species from New Mexico, two species from the Canal Zone, and six species from Durango, Mexico, only one, *Centruroides suffusus*, is decidedly poisonous to man. The venom of this species is a neurotoxin and is exceedingly rapid in its action. On rats and guinea pigs, it causes convulsions and paralysis of the respiratory system and death usually follows in from thirty minutes to an hour. On man the poison has a similar effect and is reliably reported as frequently causing death in children. So far as I know, there is only one other scorpion *(Buthus quinquestriatus)*, of Egypt and other parts of Northern Africa, that is reported to have a poison of similar potency.

The centipedes that have been studied, three species from Arkansas, one species from New Mexico (and Mexico), one species from Durango, Mexico, and one species from the Canal Zone, are all harmless so far as the effect of their poison is concerned.

A study of the Black Widow, *Latrodectus mactans*, has shown that the bite of this species causes appreciable symptoms, though apparently not death, on white rats. On man the bite produces severe muscular pain that lasts for several days, and a mild degree of paralysis which disappears in a few hours. Although the poison is not likely to produce fatal results, it may under certain circumstances be regarded as dangerous, and at best very painful in its effects.

Acknowledgments.

A complete statement including the names of all those who helped me can unfortunately not be given here. A few of those in Durango who rendered indispensable assistance in the studies made in Mexico are: Mr. David J. D. Meyers, American Consul at Durango; General Enrique R. Nájera, Governor of the State; General Enrique León; Dr. Carlos de la Pena; Dr. Isauro Venzor; Dr. A. B. McKissack; Dr. Harry Grey; Sr. Alexandro Garva, President of the Municipality; Mrs. H. V. Jackson; Mr. Oury Jackson and Mr. and Mrs. Homer C. Coen. Mr. and Mrs. Frederico C. Damm graciously allowed me a room in their home for a laboratory and took me out on field trips almost daily. Mr. and Mrs. Raymond Bell of Atotonilco; Mr. and Mrs. Frederick Palmer of El Salto; Mr. Thomas Fairburn, Mr. Walter Ohlendorf and other officials of the Tlahualilo Company, and many others who should be mentioned, rendered not only valuable assistance, but made my visit in Mexico very pleasant indeed.

Literature.*)

1. Arthus, M. — 1913. Recherches expérimentales sur le venin de Buthus quinquestriatus; in C. R. Acad. des Sciences.
2. Avendano, O. — 1926. Breve estudio de la inmunizacion con la ponzona del alacrán de Durango.
3. Baerg, W. J. — 1922. Regarding the habits of tarantulas and the effects of their poison; in Sci. Monthly, vol. 14, pp. 481—488.
4. — 1923. The Black Widow: its life history and the effects of the poison; ibid., vol. 17, pp. 535—547.
5. — 1924. The effect of some supposedly poisonus arthropods; in Annals Ent. Soc. of America, vol. 17, pp. 343—352.
6. — 1925. The effect of the venom of some supposedly poisonous arthropods of the Canal Zone; ibid., vol. 18, pp. 471—478.
7. — 1926. Regeneration in the tarantula Eurypelma californica Ausser.; ibid., vol. 19, pp. 512—513.
8. — 1928. The life cycle and mating habits of the male tarantula; in The Quarterly Rev. of Biol., vol. 3, pp. 109—116.
9. Bert, M. P. — 1865. Contribution a l'étude des venins; in Compt. Rend. Soc. Biol., p. 136; and Gazette Médicale de Paris, p. 770.
10. — 1885. Venin du scorpion (Scorpio occitanus); in Compt. Rend. Soc. Biol., p. 574.
11. Bogen, Emil. — 1926. Arachnidism; in Archives of Internal Medicine, vol. 38, pp. 623—632.
12. Bonancea, Sylvio J. — Diciembre, 1921. Nota acerca del llamado danto de los alacranes; in Revista Mexicana de Biología, tomo II, numero 2.
13. Bonnet, P. — 1927. De la parthénogénèse, de l'état de maturité sexuelle et des mues "Post-nuptiales" chez les araignées; in Bulletin de la Société Zoologique de France, Tome 52, pp. 332—351.
14. Bourne. — 1887. Scorpion virus; in Proceedings of the Royal Society, 1887; and Nature, 1887.
15. Brachetti, Felipe. — October 31, 1926. Por la primera vez se usó un suero antialacránico preparado en el Instituto Biológico de México en caso grave de picado de alacrán con muy buen éxito; in Revista Duranguena.
16. Brazil, Vital. — 1918. Soro anti-escorpionico; in Memórias do Instituto de Butantan, tomo I, fasciculo 1, pp. 47—52.
17. Brazil, Vital and Vellard, J. — 1925. Contribuicão ao estudo do das aranhas; in Memórias do Instituto de Butantan, tomo II, fasciculo unico, pp., 1—75.
18. — 1926. Contribuicão ao estudo do veneno das aranhas (continuacão); ibid., tomo III, fasciculo unico, pp. 1—59.
19. Browning, C. C. — 1901. Original investigations of spider bites; in Southern Calif. Practitioner, pp. 1—8.
20. Carillo, Rafael. — 1907. Nota sobre un enfermo picado de alacrán y curado con el suero antiponzonoso del Dr. Vergara Lope; in Gazeta Médica, tomo II, número 3 (3a serie).
21. Cavaroz, M. — 1865. Du scorpion de Durango et du cerro de los remedios; in Recueil de Memoires de Médecine Militaire, XIII, p. 327.
22. Comstock, J. H. — 1913. The Spider Book.
23. Crouse, H. W. — 1902. The venomous snakes and spiders of Texas; in Transactions of State Medical Association of Texas, pp. 1—39.
24. Dalange, M. — 1866. De piqures par les scorpions d'Afrique; in Recueil de Mémoires de Médecine et de Chirurgie Militaires, p. 136.
25. de Bellesme, Jousset. — 1870. Essai sur le venin du scorpion; in Compt. Rend., LXI, p. 407.
26. — 1971—72 (1871—72?). Essai sur le venin du scorpion; in Revue et Magazine de Zoologie. T. XXIII, 2 s.

*) This list includes, besides the papers that I have used, also a number of others listed in bibliographies in some of the papers. For the latter the reference is unfortunately often incomplete.

27. de la Pena, Carlos León, e Venzor, Isauro. — 1926. Trabajos emprendidos para la preparacion de un suero contra el envenenamiento producido por el piquete de alacran, pp. 1—17.

28. Espinosa, Amador. — 1880. Estudio sobre los efectos de la ponzona del alacrán. Mexico.

29. Ewing, H. E. — 1928. Observations on the habits and the injury caused by the bites or stings of some common North American arthropods; in Journ. Trop. Medicine, vol. 8, pp. 39—62.

30. — 1928. The scorpions of the western part of the United States with notes on those occurring in Northern Mexico; in Proc. U. S. Nat. Museum, vol. 73, pp. 1—24.

31. Faust, Edwin Stanton. — 1906. Die tierischen Gifte, p. 176.

32. Gazeta de Mexico. 29 de diciembre de 1784, 19 de abril de 1785, 12 de julio de 1785, and 20 de noviembre de 1787.

33. Guyon, M. — 1864. Du danger pour l'homme de la piqure du grand scorpion du nord de l'Afrique (Androctonus funestus); in Compt. Rend., LIX, p. 533.

34. — 1865 and 1867. Sur les accidents sur les animaux à sang chaud, mammifères et oiseaux, par le venin des scorpions; ibid., lx, 16, and ibid., lxiv, 1000.

35. Hermes, William B. — 1915. Medical and Veterinary Entomology, pp. 371—374.

36. Herrera, Mariano. — 1892. Estudio sobre el piquete del alacrán. (M. S.).

37. — Estudio sobre el alacrán de Durango.

38. Herrera, Moisés. — 1921. Los escorpiones de México; in Memorias y Revista de la Sociedad Científica "Antonio Alzate". Tomo 39, p. 137.

39. — 1923. Guia part visitar la coleccion de los Aracnidos, Miriapodos e Insectos, pp. 8—9, 11, 13—16, 18.

40. Houssay, B. A. — 1919. Action physiologique du venin des scorpions (Buthus quinquestriatus et Tytius bahiensis); in Journ. Physiologie et Pathologie générale, tomo xviii, número 2.

41. Iwano, S. — 1917. On the chemical character of scorpion venom from Manchuria; in Kyoto Igaku Zassi, xiv.

42. Jackson, H. V. — 1910. A preliminary study of the poisonous scorpion including a review of some recent literature and personal experiences; in Interstate Medical Journal, vol. xvii, no. 7.

43. — 1911. Some further study of scorpion venom; in Alianza Científica Universal Boletin del comite, Regional del Estado de Durango, tomo ii, numero 2, Durango, Abril 1.

44. Kellogg, V. L. — 1915. Spider Poison; in Journ. Parasit., vol. 1, pp. 110—111.

45. Kopstein, F. — 1927. The poisonousness of the Javanese giant scorpion Heterometrus cyaneus; in Mededeelungen v. d. Dienst d. Volksgezondheid in Nederlandsch-India; Foreign Ed., Part III, pp. 504—513.

46. Kubota, Seiko. — 1918. An experimental study of the venom of the Manchurian scorpion; in Journ. Pharmacology and Experimental Therapeutics, vol. xi, no. 5, pp. 379—388.

47. — 1918. On the toxicity of the venom of the Mexican (Durango) scorpion as compared with that of the Chinese scorpion; ibid., vol. xi, no. 6.

48. Laffuie, Joyeux J. — 1882 and 1883. Sur l'appareil venimaux et le venin du scorpion; in Archiv. de Zoologie expér., II, 733 (1883) and Compt. Rend., 1882, xcv, p. 866.

49. — 1883. Sur l'appareil venimeux et le venin du scorpion. Th. de Med.

50. Laforgue, E. — Le scorpion d'Algérie et les accidents d'evinemation dus à sa piqure; in Revue de médecine de l'Afrique du Nord.

51. Lope, Daniel Vergara. — 1904. Estudio sobre algunos animales ponzonosos de Mexico. Informe del Instituto Médico Nacional. México.

52. Maupertuis, M. de. — 1731. Expériences sur les scorpions. Histoire de l'Académie, p. 223.

53. McCook, Henry C. — 1893. American spiders and their spinning work.

54. Milles, L. H. — 1912. Mexican scorpions and the treatment of scorpion sting; in Boston M. and S. J., vol. clxvii, p. 183.

55. Nicolle, C. et G. Gatouillard. — 1905. Sur le venin d'un scorpion commun de Tunisie (Heterometrus maurus); in C. R. Soc. de Biologie, p. 100.

56. Ocaranza, Fernando. — 1923. Memoria preliminar acerca de la ponzona de los alacranes de México; in Boletin del Instituto de Higiene, Departamento de Salubridad Publica, tomo I, número 2, pp. 33—50.

57. — 1923. Memoria preliminar acerca de la ponzona de los alacranes de México; in Revista Mexicana de Biología, tomo III, numero 5, pp. 179—193.

58. — 1923. Estudio experimental acerca de la acción fisiológica de la ponzona de los alacranes de México. Primera memoria. Veneno del *Centrurus exilicauda.* Inoculación al cuy; ibid., tomo III, número 5, pp. 194, 200—205.

59. — 1923. Contribución experimental para el estudio de la acción fisiológica de la ponzona de los alacranes de México. Segunda memoria. Ponzona del alacrán de Durango *(Centrurus exilicauda),* Rata blanca; ibid., tomo III, número 5, p. 201.

60. Ochoterena, Isaac. — 1910. Estudio sobre el alacrán de Durango; in Boletin del Comité Regional del Estado de Durango, Alianza Científica Universal, tomo 1, numero 4.

61. — 1910. El alacrán de Durango; in Memorias de la Sociedad Científica "Antonio Alzate", Tomo 37, p. 215.

62. Palacio, Fernando Gómez. — 1905. Suero anti-ponzonoso. Tesis Escuela Nacional de Medicina, Mexico.

63. Petrunkevitch, Alexander. — 1911. Sense of sight, courtship and mating in *Dugesiella hentzi* (Girard), a theraphosid spider from Texas; in Zool. Jahrb. Syst., Band III, pp. 355—375.

64. — 1925. Arachnida from Panama; in Trans. Conn. Academy of Arts and Sciences, vol. 27, pp. 51—248.

65. — 1926. Tarantula versus tarantula-hawk: a study in instinct; in Journ. of Exp. Zool., vol. 45, pp. 367—393.

66. Phisalix, C. et Varigny, H. de. — 1896. Reserches expérimentales sur le venin du scorpion; in Bul. du Muséum d'Histoire Natur., ii, p. 67.

67. Phisalix, Marie. — 1922. Animaux venimeux et venins. Paris.

68. Pierce, W. D. — 1921. Sanitary Entomology, pp. 461—466.

69. Riley, W. A. and Johannsen, O. A. — 1915. Handbook of Medical Entomology, pp. 14—18.

70. Romero, F. J. — 1900. El alacrán de los tierras calientes; in Crónica Médica Mexicana, tomo iii, número 7, Enero de 1900.

71. Sanarelli, G. — 1888 and 1889. Di una particolar alterazione dei globuli rossi nucleati, prodotta dal veleno dello scorpio europaeus; in Bollettino della sezione dei cultiri delle scienze mediche in Siena, 1888, 202 and Centralblatt f. klin. Med., 1889, x, p. 153.

72. Sánchez, Jesús. — 1887. Datos para la Zoologia Médica Mexicana; in Gaceta Médica, tomo xxii, nùmero 6.

73. — 1892. Nota relative a los virus, venenos o ponzonas de algunos animales que viven en México; ibid., tomo xxvii, número 11.

74. — 1893. Datos para la Zoología Medica Mexícana. Arácnidos é Insectos, pp. 55—79.

75. Santa Maria, Carlos. Estudio sobre el alacrán de Durango.

76. — 1893. Plática sobre el piquete del alacrán de Durango, en el Primer Congreso Médico Mexícano, pp. 1—12.

77. — 1894. Algo más sobre el piquete del alacrán de Durango. Para el segundo congreso médico mexicano, pp. 1—8.

78. Schultze, W. — 1927. Biology of the large Philippine forest scorpion; in Philippine Journ. of Sci., vol. 32, pp. 375—388.

79. Thompson, F. H. — 1886. On the effect of scorpion stings; in Proc. Acad. of Nat. Science of Philadelphia, p. 299.

80. Todd, C. — 1909. An antiserum for scorpion venom; in Journ. of Hygiene.

81. Valentin, G. — 1876. Einige Erfahrungen über die Giftwirkung des nordafrikanischen Skorpions; in Zeitschr. f. Biolog., xii, 170—179.

82. Vorhies, Chas. T. — 1917. Poisonous animals of the desert; in Ariz. Agr. Exp. Sta., Bull., No. 83, pp. 387—391.

83. Warburton, Cecil. — 1912. Spiders, pp. 99—104.

84. Wilson, W. H. — 1904. The physiological action of scorpion venom; in Journ. Physiology, Cambridge.

85. — 1904. On the venom of scorpions; in Records of the Egyptian Government School of Medicine, vol. ii, pp. 11—44.

86. Zarraca, Fernando and Faz, Francisco. — 1923. Experiencias acerca de la ponzona del alacrán de Durango; in Boletin del Instituto de Higiene, Departamento de Salubridad Publica, tomo 1, número 1, pp. 7—11.

Biological Notes on the Pink Bollworm (Pectinophora gossypiella Saunders) in Texas.

F. A. Fenton, Entomologist,
Cotton Insect Investigations, Bureau of Entomology, El Paso, Texas *).

On July 1, 1927, most of the research work dealing with the pink bollworm was transferred from the Federal Horticultural Board to the Bureau of Entomology, and the writer was detailed to supervise the project, with headquarters at El Paso, Texas. The season of 1927 was largely spent in a survey of the infested area to determine the nature of the problem and the best place for the location of a biological laboratory. A series of small cotton plantings had already been made by Mr. L. F. Curl, Assistant Plant Quarantine Inspector, to determine whether or not the plants could become infested by the pink bollworm. Some Thurberia cotton had also been planted at Castolon, Texas, for this same reason.

At Castolon, where the biological work was conducted, all cotton is irrigated and is of the Acala variety. The soil is heavy to sandy adobe. The surrounding country is a mountainous desert with an altitude at Castolon of 2124 feat. No complete temperature data are available other than those secured since March 1928. They are shown in Table I.

At the present time the greatest need for information is for the use of the Plant Quarantine and Control Administration, formerly the Federal Horticultural Board, in order that this organization can plan and carry out its quarantine and repressive measures in the best possible manner. The problem of control is not pressing in spite of the fact that, although some 570,500 acres in the States of Texas, New Mexico and Arizona are infested, very little commercial damage has been done except in Presidio and Brewster counties in Texas. These counties comprise an immense area in South-west Texas known as the "Big Bend". In this region there are from 7,000 to 8,000 acres of cotton planted along the Rio Grande River, with many fields heavily infested with the pink bollworm.

Briefly, the most important points on which information is needed are as follows:

---

*) The writer is greatly indebted to Mr. L. F. Curl, Assistant Plant Quarantine Inspector, Plant Quarantine & Control Administration, Marfa, Texas, for notes on the flight experiment. This work was planned and carried out by Mr. Curl. He is also indebted to the Division of Entomology, Texas Experiment Station, now cooperating with the Bureau of Entomology in the research on this project for assistance in carrying out part of the experimental work at Castolon, Texas.

1. The flight or wind carriage of the moths.
2. Is cotton the only host plant capable of carrying the species over the winter in this country?
3. What are the best methods to use in field clean-up operations?

These questions are discussed more fully in the following paragraphs with statements as to what has been accomplished.

1. The flight or wind carriage of the moths.

Whether or not the moths fly or can be carried long distances by air currents, under what conditions this occurs and from what centers the species spreads, are questions of paramount importance in the delimiting of quarantine areas and also in the establishment of non-cotton zones.

The fact that the moths are small and fragile makes it difficult, if not impossible, to accomplish much by liberating and recapturing marked individuals. Moreover, we are more interested in long distance spread than local, owing to the extremely isolated nature of the present infested areas from each other and from the main cotton belt. The desert and mountainous nature of the country also adds to the difficulty of determining much by this method. We have therefore been forced to gather data on this point in other ways, and as the species has apparently but one host plant, the trap crop method was used, the idea being that if isolated plantings of cotton could be infested when all possible means other than flight or wind carriage were excluded, then we must conclude that the species was either carried to the plot by air currents or that the moths flew that far. With this in mind, Mr. Curl planted nine small isolated plots of cotton as far east as Marathon, Texas, and west as far as Van Horn, Texas, all within the quarantine area, but all from 45 to 60 miles distant from the nearest cotton fields other than those in the Big Bend, and from 33¾ to 75 miles distant from the heavily infested cotton fields in the Big Bend (Tabl. I.). The seed planted was all from non-infested territory and care was used in visiting the plots to see that no infested material was brought near them. The plantings were all very small, the greatest number of bolls produced in any one plot being 525, while the usual number was around 100. The plots were also located in isolated sections, usually in a ranch garden, and were not near the roads used in travel from the cotton fields along the Rio Grande in the Big Bend. In November 1927, 8 of the 9 plots were found infested, the infestation ranging from 1.2 to 27.6%. Some of the plots were located nearer to large amounts of stored seed cotton than to cotton fields, but even here the distances were great, and moreover, this seed cotton had been sterilized by the heat treatment prescribed for killing pink bollworms. The heaviest infested plots were the farthest away from the stored seed and to the west against prevailing winds. Three of the 4 heaviest infested fields were from 33¾ miles to 37½ miles from the heavily infested fields in the Big Bend and in these the infestation ranged from 18.3 to 27.6%. Five plots which were from 60 to 75 miles from the Big Bend cotton areas averaged from 1.2 to 10.4%, and one plot was not infested. One plot, however, had an infestation of 27.5% and was 60 miles from the fields in the Big Bend and 50 miles from the nearest cotton. It is interesting to note that the

only plot not infested was located under a high cliff where wind-blown moths would be less likely to find it.

Owing to the smallness of the plots, their isolation, and the great care taken in excluding means of infestation, it is difficult to account for these infestations in any other way than by flight or wind carriage of the moths.

2. Is cotton the only host plant capable of carrying the species over the winter in the present infested territory?

The importance of determining the above point when considering non-cotton zones or clean-up operations is readily seen. While considerable work on this subject has been planned, the only work done last year was to plant Thurberia seed *(Thurberia thespesioides)* at Castolon, Texas, to determine if this species of plant could become infested in the presence of an exceedingly heavy pink bollworm infestation in cotton. This was done in view of the fact that the pink bollworm was found in Arizona in 1926 and in a region where cultivated cotton is not far from mountains where Thurberia plants occur. The Thurberia seed was sterilized to destroy any possible weevil infestation and planted in both sandy and adobe soils at Castolon. Germination was secured only in sandy soil in a garden fairly well isolated by woods from any cotton and about 100 yards from the nearest cotton.

There were about six large vigorous Thurberia plants that grew to maturity, bloomed and fruited heavily, each plant having several hundred bolls. These plants were watched by Mr. Curl, but no extensive boll examinations were made, that there might be plenty of material left at the end of the season for a careful examination. In late September, suspicious signs of pink bollworm infestation were found by Mr. W. B. Rogers, an associate of Mr. Curl, and on October 20, Mr. Rogers and the writer examined several dozen bolls and found two typical mature larvae and one about half grown. These were later identified by a specialist (Carl Heinrich) as pink bollworm larvae.

On November 10, 1927, 932 Thurberia bolls were placed in 3 cages to determine if the species could be carried through the winter in this plant. These bolls had been collected November 4 and 10. The soil was sifted and every precaution was taken to insure that there would be no other infested material in the cages. The bolls were placed either on the surface of the ground or just under the soil. Mr. T. P. Cassidy, who is familiar with Thurberia cotton in Arizona, assisted in caging the bolls and every effort was made to duplicate natural conditions in so far as that was possible. An examination of 130 Thurberia bolls was made November 27 to determine the percentage of infestation. There were two living larvae found in them. One boll had a typical exit hole. There was a total of 5 infested bolls, making the infestation 3.85%. The fact that the infestation was so small in the presence of almost a 100% cotton boll infestation indicates that Thurberia cotton is not a favored host plant. There were indications, however, that larvae had entered bolls, but owing to the rapid maturity of the latter had died. The presence

of the exit hole would indicate that under certain conditions the larva coming to maturity in the Thurberia boll might leave it and pass the winter in the soil in the vicinity of the plant. The injury to Thurberia cotton consists of several of the seeds being partly eaten and fastened together within the boll.

The cages containing Thurberia bolls were irrigated June 12 and have been examined daily since March 1928, but no moths have emerged from any of the bolls up to July 18. It is therefore not certain at the present time, whether or not the species can pass the winter successfully in Thurberia bolls, even though the latter can become infested in the summer.

3. What are the best methods to use in field clean-up operations?

In considering the above, the first question to be answered is in just what part of the field and in what proportions the over-wintering or long cycle larvae are found. To determine this point, December 14 to 16, 1927, a careful plant and soil examination was made in representative parts of a heavily infested field at Castolon. The results of the examination (Table II) showed that, allowing six plants per two square yards of field, there were 5 dead larvae and pupae and 63 living larvae in the bolls and other forms on the plants. In two square yards of surface trash, there were 3 empty cocoons and pupal cases and 24 live larvae. On the plant roots of 100 plants, or 33 square yards, there were 42 empty cocoons and pupal cases and 11 living larvae. In two square yards of soil, there were 3 living larvae, one of which was in a typical resting stage cocoon. With the preceding figures reduced to percentage bases, 69.5% of the living larvae were on the plants and 26.5% in the surface trash; or 96% above the ground; while 0.7% were on the plant roots and 3.3% in the soil; or a total of 4% underground. This would indicate that any method of field clean-up that did not take into consideration stages in the soil would not be 100% effective, unless soil conditions were such as to produce complete mortality. The interesting biological feature discovered in the examination referred to was the number of cocoons of both types found on the tap roots of the plants. In the rather heavy adobe soil, which forms a hard crust after irrigation, the movement of the plant's main stem by the wind produces an opening all around the crown, so that is is easy for the larva in seeking a sheltered place in which to spin up to continue on down the stem into the soil to the roots. Whether or not this would hold true in the sandy soils is not known.

In order to determine long cycle larval mortality under irrigation at different times and with different dates of plowing, as well as combinations of the two, the following experiment was started December 1, 1927.

A small field about 60 by 60 feet where there had been no cotton was cleared and divided into three plots of about equal size separated by borders of dirt so that each could be irrigated separately. December 1 to 6, twelve wire cylinders were installed in each of the three plots. Each cylinder was made of 14 mesh wire about 20 inches in diameter and 18 inches high, with neither top nor bottom. One end of each cylinder was buried about 6 inches in the ground. Seventy-five cotton bollies were

placed in each, the larval population of which had been estimated at 3.21 fully developed live larvae per boll, or an average of 240.75 per cylinder, totaling 8,667 larvae in all cylinders. The bolls in 4 cylinders in each plot were then buried to a depth of 4 to 5 inches and one plot was irrigated December 6. This plot was flooted to a depth of about 7 inches. The bolls on the surface floated and were never completely soaked. It took the water about 4 hours to soak into the soil, which was of the heavy adobe type.

On March 8, 1928, the bolls in 4 of the 8 remaining cylinders containing unburied bolls in each of the 3 plots, or a total of 12 cylinders in all, were buried to a depth of 4 to 5 inches and the second plot flooded in the same manner as the first had been the previous winter. Thereafter the plots that had been irrigated were flooded again on May 12 and June 12. This left one plot that was never irrigated. There were thus winter and spring buried bolls and bolls not buried, in each of the 3 plots; i. e. winter irrigated, spring irrigated and not irrigated.

The first examination was made March 5 to 15, 1928, to determine winter mortality caused by different treatments (Table III). The results showed very little difference in the mortality of any of the treatments with the exception of the plot that had been irrigated in December. Here there were only 2 living larvae recovered out of a possible 240.75, or a mortality of 99.17%. The mortality in the others ranged from 38.53 to 43.51% There had been no moth emergence at that date.

The second examination was made April 23 to 25. At this time there had been considerable moth emergence in most of the cages installed to determine this point. As the pupal cases are very fragile, no attempt was made to estimate emergence from cylinders. The results are shown in Table IV. The mortality was highest in the winter buried and winter irrigated plot, only one live larva being found, showing a mortality of 99.58%. The lowest mortality was found in the winter irrigated and spring buried bolls, namely, 75.49. By April 23, on which date the last of the bolls were collected for examination, a total of 162 moths had emerged from the 9 emergence cages, and this was 41.75% of the total emergence. As there were 5,778 larvae installed in the emergence trays, it is seen at once that the per cent of emergence was comparatively small. Only 2 moths had emerged from the tray in the winter buried and winter irrigated plot and 6 in the winter irrigated and not buried plot.

The third examination was made May 21 to 23 (Table V). A mortality of 100 % had been reached in the winter irrigated-winter buried plot and spring buried-not irrigated plot. In all the rest, the mortality had greatly increased. At this date 86.86 % of the emergence had taken place in the emergence cages or a total of 337 moths. There had been no further emergence in the winter buried and irrigated plot. Emergence had been very light in the not irrigated-spring buried, not irrigated-not buried and winter irrigated-not buried plots.

The last examination was made June 22 to 26 and no live stages were found in any of the cylinders. June 26, 97.68 % of the total moth emergence had taken place and the only emergence cages active after this date were spring irrigated-not buried and winter irrigated-not buried.

The results of this experiment indicated that a very high morality resulted from winter irrigation following winter burial, but that winter irrigation or winter burial alone were not effective, nor were any of the other methods effective.

Summarizing the results (Table VI) 3 living stages were found in the winter irrigated-winter buried plot during the four examinations, but the differences in the others were slight except in the winter irrigated-spring buried plot, where 212 living stages were found. Tabulating the results according to time of irrigation, the greatest number were found in the spring irrigated and least in the winter irrigated plots, while according to time of burial the greatest number were found in the spring buried and least in the winter buried plots. Eleven hundred and twenty six stages were found in the March examination*, 187 in the April, 16 in the May and none in the June examination.

In order to determine survival in the dried bolls on the plants two wire cages, four feet in all dimensions, were constructed and plants with infested bolls placed in the cages. The number of living mature larvae per boll was estimated to be 3.7 and the plants placed in the two cages contained approximately 2,227 live fully developed larvae.

March 9, when 75 bolls were taken from one cage and examined, 198 living larvae were recovered out of a possible 277.5, giving a mortality of 28.65 %. This mortality was much less than that in any of the wire cylinder cages at that time.

The second examination was made April 26, when 166 living stages were found in 50 bolls out of 220 stages, or a mortality of 20.73 %, since 4.82 % of the 220 had been found dead at date of installation**). Two pupal cases that were found indicated that there had been a slight emergence.

The third examination was made May 23, when 72 living stages were found, or a mortality since date of installation of 56.52 %.

The fourth examination was made June 26, when 38 living stages were found, making a mortality of 71.48 %. As dead larvae were very easily overlooked in the last two examinations owing to disintegration, and as the total stages found was less than estimated at the date of installation, it is probable that the percentage of mortality was greater in these examinations than is here indicated.

Much of the mortality in the bolls on the plants was caused by predaceous mites, but even at that it was much less than in the bolls on or in the soil and, moreover, there was very little pupation. Whereas on June 26, all stages in the cylinders had either emerged or died, there was still apparently a fairly large larval population in the dried bolls. This would indicate that in the vicinity of Castolon old standing stalks are dangerous sources of infestation, as the winter survival is large and emergence is delayed until the cotton plant is in the right stage to be infested.

In order to determine the time and rate of moth emergence as well as to check up on the actual final mortality in the cylinder cages, a tray

---

*) See foot-note explaining Table VI.

**) After the first examination the percentage of mortality was figured from the total number of stages found.

containing 200 bolls was installed with each kind of treatment. The living adult larval population of each tray was estimated to be 642, so there were 5,778 larvae in the 9 trays. In March the screen wire was removed from the tops of the trays and black cloth replaced with a wire fly trap in the center to catch any emerging moths. These traps were examined each morning, at noon and at night to determine moth emergence. The first moths emerged March 27 and the last July 2, a total of 388 out of 5,778, or an actual survival under all conditions of 6.72%. The total emergence from the irrigated plots was 31.7, of which 237 came from the spring irrigated plot, and 71 moths emerged from the non-irrigated plot (Table VII). The total emergence from the spring buried plots was 144, from the winter buried 116 and the not buried 128. It is thus seen that the emergence was heaviest in the spring irrigated and spring buried plots. The emergence according to months was as follows:

March	3
April	255
May	100
June	28
July	2

The period of heaviest emergence extended from April 14 to April 30, with a peak occurring April 25.

Summary.

In 1927, eight out of nine small isolated plots of cotton scattered from Van Horn, Texas, to Marathon, Texas, were infested with the pink bollworm. At the present time, no explanation for the infestation is offered other than that of the moths flying or being carried by air currents from the nearest infested fields, which were 33¾ to 60 miles away.

Thurberia thespesioides, a native wild cotton in Arizona, became infested at Castolon, Texas, in the presence of a heavy pink bollworm infestation of cultivated cotton. No emergence has been secured as yet from infested bolls of this plant, so it is not yet certain whether or not the pink bollworm can successfully hibernate in bolls of this plant.

At Castolon, 96 % of the over-wintering long cycle larvae were found either in the cotton forms on the plants or in the surface trash on the ground and 4 % in the soil or on the tap roots of the plants.

The larvae may spin either summer or resting stage cocoons on the tap roots of the cotton plants.

Of all combinations of treatments to destroy over-wintering larvae in the soil, none were effective except early winter burial followed shortly by irrigation. With this treatment, 99.17 % mortality was secured from December, 1927, to March 15, 1928.

The survival up to June 26 in dried bolls on the plants was greater than in bolls on or in the soil. Pupation was also delayed under this condition in 1928.

Emergence of moths from bolls on or in the soil at Castolon, Texas, extended from March 27 to July 2, 1928, the heaviest emergence occurring from April 14 to 30 and the peak April 25. Emergence was heaviest in the spring irrigated plot and least in the non-irrigated plot and was heaviest in the spring buried plot and least where the bolls were winter buried. Only

3 moths emerged from the early winter buried-winter irrigated plot; this result checking up closely with the results of the cylinder examinations.

There was a total survival under all conditions of 6.72 % at Castolon, Texas, according to emergence records.

Table I. — Climatological Records, Castolon, Texas, 1928.

	April	May	June
Maximum temperature	10.37	102.5	113
Minimum "	27	48.5	63
Mean maximum temperature	76.49	93.45	103.51
" minimum "	43.35	62 75	72.78
" "	60.26	78.1	88.15
Rainfall	0	1.8	0

Table II. — Field Distribution of Long-cycle Larvae of *Pectinophora gossypiella* Saunders, Castolon, Texas, December 14—16, 1927.

Distribution	Quantity examined	Empty cocoons and pupal cases	Dead larvae and pupae	Living larvae	No. of living larvae per sq. yd.	Per cent of living larvae per sq. yd.
On plants	6 plants	—	5	63	31.5	69.5
In surface trash	2 sq. yds.	3	—	24	12	26.5
On plant roots	100 plants	42	—	11	0 33	0.7
In soil	2 sq. yds.	—	—	3	1.5	3.3
Total		45	5	101	45.33	

Table III. — Results of Cylinder Examination for Determination of Mortality of *Pectinophora gossypiella* Saunders, Castolon, Texas, March 5—15, 1928.

Treatment	Estimated no. larvae installed	Winter irrigated plot		Not irrigated plot	
		No. stages *) alive	Per cent mortality	No. stages *) alive	Per cent mortality
Bolls on surface	240.75	148*	38.53	136*	43.51
Winter buried bolls	240.75	2	99.17	142*	41.02

*) Includes living larvae and pupae.

Table IV. — Results of Cylinder and Cage Examination for Determination of Mortality of *Pectinophora gossypiella* Saunders, Castolon, Texas, April 23—25, 1928.

Treatment	Estimated no. larvae per cylinder	Winter irrigated plot		Spring irrigated plot		Not irrigated plot	
		No. stages *) alive	Per cent mortality	No. stages *) alive	Per cent mortality	No. stages *) alive	Per cent mortality
Bolls on surface	240.75	18	92.52	18	92.52	5	97.92
Winter buried bolls	240.75	1	99.59	29	87.95	27	88.79
Spring buried bolls	240.75	59	75.49	10	95.85	20	91.69

*) Larvae, pupae and moths. Note: the above figures do not represent the true mortality, as there had been a considerable emergence.

Table V. — Results of Cylinder and Cage Examination for Determination of Mortality of *Pectinophora gossypiella* Saunders, Castolon, Texas, May 21—23, 1928.

Treatment	Estimated no. larvae per cylinder	Winter irrigated Plot		Spring irrigated Plot		Not irrigated Blot	
		No. stages *) alive	Per cent mortality	No. stages *) alive	Per cent mortality	No. stages *) alive	Per cent mortality
Bolls on surface	240.75	1	99.59	5	97.92	2	99.17
Winter buried bolls	240.75	0	100	1	99.59	1	99.59
Spring buried bolls	240.75	5	97 92	1	99.59	0	100

*) Larvae, pupae and moths. Note: the above figures do not represent the true mortality, as there had been a considerable emergence.

Table VI. — Number of Live Stages of *Pectinophora gossypiella* Saunders found in Cylinder Examinations, Castolon, Texas, 1928.

Treatment		Date of examination				
		March 5—15	April 23—25	May 21—23	Totals	
[Spring irrigated]	Not buried	136 *)	18	5	159	
	Spring buried	136 *)	10	1	147	
	Winter buried	142 **)	29	1	172	478
Winter irrigated	Not buried	148	18	1	167	
	Spring buried	148 ***)	59	5	212	
	Winter buried	2	1	0	3.	382
Not irrigated	Not buried	136	5	2	143	
	Spring buried	136 *)	20	0	156	
	Winter buried	142	27	1	170	469
Totals		1126	187	16	1329	

*) Not irrigated-Not buried, March examination.
**) Not irrigated-Winter buried, March examination.
***) Winter irrigated-Not buried, March examination.

Table VII. — Emergence of *Pectinophora gossypiella* Saunders from Cotton Bollies, Castolon, Texas. 1928.

Treatment		Total emergence
Spring irrigated	Not buried	87
	Spring buried	75
	Winter buried	75
Winter irrigated	Not buried	28
	Spring buried	50
	Winter buried	2
Not irrigated	Not buried	13
	Spring buried	19
	Winter buried	39

Local Conditions as Influencing Recommendations for the Control of Sugar-cane Insects.

T. E. Holloway, Senior Entomologist.
Bureau of Entomology, U. S. Department of Agriculture, New Orleans, La.

Some of the insect pests of sugar cane are of wide distribution. The weevil borer, *Rhabdocnemis obscura* Boisd., occurs in Hawaii, Australia, New Guinea, Fiji, and elsewhere (1), while the moth borers, *Diatraea spp.*, are found principally in the Americas, Java, and the Philippine Islands (2). Other pests, such as the froghopper, *Tomaspis varia* F. (3), are important locally, but they seem rather unimportant when compared with the insect plagues which afflict countries and continents.

It has become evident, however, that though an insect pest may be common to many countries, the control measures used against it must be adapted to local conditions everywhere. It is unwise, therefore, to recommend for a foreign country control measures which may be satisfactory at home. A foreign planter will sometimes appeal to an entomologist to offer suggestions for control, but in this case it is the safer course to advise that a competent person be employed to investigate the insects and their environment in their native land.

For instance, control measures suitable for use in a subtropical climate will probably prove ineffective in a tropical one. The greater or less abundance of labor available in a given region may determine whether a recommendation is practical or not. The necessity for preservation of local parasites may make changes necessary. The writer has attempted in this paper to note several instances of control measures which are effective in one country though ineffective in another. With different workers in the various countries, there is, of course, a chance that individual preferences may determine whether a certain procedure is advised, but it can safely be assumed that in most cases the recommendations are based on the insects in question and their ecology.

Owing to cheap labor, hand collection of larvae and pupae of borers appears to be satisfactory and necessary in British Guinea (4), but it is favored in probably no other country. The destruction of young plants killed by borers ("dead hearts") has been recommended in Louisiana, but this practise has never met with much favor among sugar planters, and there is some doubt of its efficacy. Plank (5) finds that in Cuba the cutting of "dead hearts" resulted not only in the destruction of the borers, but in a reduction in the abundance of their parasites.

The non-burning of the "trash" left on the fields after cutting the cane has been found to be advantageous in Louisiana (6), Porto Rico (7),

and, at least by way of benefiting the soil, in Argentina (8). Van Zwaluwenburg (9), however, tried it in western Mexico without obtaining encouraging results. Possibly due to the arid climate of that region, the trash did not rot and thus became detrimental to the growth of the cane. The theory involved is that the burning of this mass of leaves tends to destroy the parasites of the moth borer.

Parasite introduction is especially successful in Hawaii. The Hawaiian entomologists have given this method a better test than have entomologists studying sugar-cane insects elsewhere, and much credit is due them and the progressive planters of their group of islands. Climatic and other conditions are favorable for parasite introduction, but without the persistence of the entomologists and the sugar planters, this mode of attack would probably have resulted in failure.

The insects associated with a pest should be considered when control measures are planned. The mealybug, *Pseudococcus boninsis* Kuw., has been controlled in Louisiana by controlling the Argentine ant, which provides it with conditions favorable to its multiplication (10). In Georgia, however, the Argentine ant does not occur in the sugar-cane fields, but the native ants encourage the multiplication of the mealy bug, and as no control measures are known for the several native ants present, other means of controlling the mealybug had to be devised (11). Planting uninfested seed cane in uninfested fields at some distance from any infested ones was found to be a satisfactory solution of the problem.

The presence of growing corn is believed to be harmful on sugar plantations in Louisiana, where one-third of the acreage is devoted to this crop. Corn in Louisiana is the favorite food plant of the moth borer. It also harbors the corn aphis, *Aphis maidis* Fitch, the only known vector of sugar-cane mosaic disease (12). In contrast, Stahl (13) finds that the planting of corn cannot spread the mosaic disease in Cuba, as it appears that the disease causing striping of the leaves of corn in Cuba is distinct from the mosaic disease which affects sugar cane.

The treatment of "seed cane" seems to be important in Louisiana and possibly it will be found of value in other subtropical countries, though in Cuba it would probably amount to little. Two methods of treatment are available—the immersion of the stalks for twenty minutes in water heated to 120 degrees F, and a soaking for seventy-two hours in water of ordinary temperatures. A much smaller proportion of cane is annually planted in Cuba than in Louisiana, and the amount of seed cane treated would be insignificant and of little importance in control. Also, due to the absence of a dormant season, many insects would be in the adult stage and therefore not treated.

The difference between tropical and semi-tropical countries is well brought out in Wolcott's (14) recommendation to *plant* seed cane infested by the moth borer, *Diatraea saccharalis* Fab. As Wolcott states: "The moth can ordinarily not emerge from seed which is covered by even so little as an inch of soil, while if clean seed is selected, the discarded (infested) seed is invariably left at the edge of the field where the moths have no difficulty on emergence in ovipositing on the young shoots that are coming up from the healthy seed that was planted". In Louisiana, on the other hand, such a practice would accomplish nothing, because the soil

is purposely scraped from the seed pieces in the spring to allow the heat of the sun to reach the cane and thus hasten germination. This practice happens to be favorable to the emergence of moths of the borer.

Cutting the cane low is important in Louisiana (6), but is probably less so in the tropics. A few borers left in tall stubble pass the winter successfully in Louisiana and may be the progenitors of a considerable population the following year, but in tropical countries a few borers in stubble are only a small proportion of the total number of borers normally present.

The "pink borer" *Sesamia vuteria* Stoll, in Mauritius spends its early stages in grass, and the elimination of grass from the fields results in its complete control (15). In this case a peculiarity of the insect, which is probably not duplicated in any other sugar country, accounts for the success of the local control recommendation where it is adopted. Unfortunately the shortage of labor largely prevents this recommendation from being put into practice.

The rotation of crops is something which has the approval of scientific workers but not of sugar planters. Louisiana has a rotation that includes practically only corn and sugar cane, which is probably worse than no rotation at all from the point of view of the entomologist, the pathologist and the soil scientist. In Mauritius, however, crop rotation is recommended against the "pink borer" noted above (15), this being an alternative measure to the elimination of grasses.

The planting of large blocks of cane has been advocated in British Guiana (4). The present system provides an intermingling of fields at all stages of growth, so that when a field of mature cane is cut the insects easily migrate to an adjoining field of younger plants. In a subtropical country, where all the cane germinates after the winter season and is therefore at the same stage of growth, the planting of cane in large blocks would be of no value.

The sugar cane entomologist is confronted with a different problem in each of the different countries he visits. The temptation, on taking a position in a new country, is naturally to make a showing by recommending the old familiar control measures, but this is a dangerous procedure. It is likely to lead to embarrassment and the complete withdrawal of the original recommendations when the significant facts in the new region become known.

Literature.

1. Muir, F., and Swezey, O. H. — 1916. The Cane Borer Beetle in Hawaii and Its Control by Natural Enemies: Hawaiian Sugar Planters Asso. Exp. Stat. Ent. Ser., Bul. No. 13, 102 p., illus.
2. Holloway, T. E., and Loftin, U. C. — 1919. The Sugar Cane Moth Borer: U. S. Dept. Agr., Bul. 746, 74 p., illus.
3. Urich, F. W. — 1913. The Sugar-Cane Froghopper (*Tomaspis varia* Fabr.) and Biological Notes on Some Cercopids of Trinidad: Board of Agriculture, Trinidad and Tobago, Circ. No. 9, 30 p., illus.
4. Wolcott, George N. — 1913. Report on a Trip to Demerara, Trinidad and Barbados during the Winter of 1913; in Journ. Econ. Ent. 6: p. 443—457.
5. Plank, H. K. — 1927. Cutting Out Dead Hearts in Stalkborer Control; in Proc. and Conf. Internat. Soc. Sugar-Cane Techs., pp. 62—63.
6. Holloway, T. E., Haley, W. E., and Loftin, U. C. — 1928. The Sugar-Cane Moth Borer in the United States: U. S. Department Agr., Tech. Bul. 41, 76 p., illus.

7. Wolcott, George N. — 1915. The Influence of Rainfall and the Non-burning of trash on the Abundance of *Diatraea saccharalis;* Porto Rico Bd. Commrs. Agr. Insular Expt. Stat. Rio Piedras, Circ. 7, 6 p., illus.
8. Cross, William E. — 1928. Ensayos Sobre el Cultivo de la Canea sin Quemar la Maloja; in Revista Ind. y Agr. de Tucuman, 18, pp. 116—123.
9. Van Zwaluwenburg, R. H. — 1923. Field Experiments in Borer Control, 1921—1923. Ent. Ser., Memo No. 1, 8 p. (A mimeographed report to United Sugar Companies, Las Mochis, Sin., Mexico.
10. Barber, Ernest R. — 1923. The Sugar Cane Mealybug and its Control in Louisiana: La. State Univ., La. Bul. 185, 16 p., illus.
11. Holloway, T. E., and Ingram, J. W. — 1926. The Sugar Cane Mealybug in Georgia; in Planter and Sugar Manufacturer, 77, pp. 330—331.
12. Brandes, E. W. — 1923. Mechanics of Inoculation with Sugar Cane Mosaic by Insect Vectors; in Journ. Agr. Res 23, pp. 279—283, illus.
13. Stahl, C. F. — 1927. Corn Stripe Disease in Cuba not Identical with Sugar Cane Mosaic: Tropical Plant Research Foundation, Bul. No. 7, 10 p., illus.
14. Wolcott, George N. — 1922. The Status of Entomology in Porto Rico; in the Journal of the Dept. Agr. and Labor of Porto Rico, 6, No. 2, pp. 3—11.
15. de Charmoy, D. D'Emmerez. — 1917. Moth Borers Affecting Sugar-Cane in Mauritius: Dept. Agr. Mauritius, Sci. Ser., Bul. No. 5, p. 27, illus.

The Cotton Flea Hopper (Psallus seriatus).*)

W. V. King, U. S. Bureau of Entomology, Mound, La.

Of the various plant sucking insects which are found on the cotton plant, four species of one family, the *Miridae,* have been proven capable of producing injury of serious economic importance. One of these, *Adelphocoris rapidus,* has long been listed as one of the minor pests of cotton with occasional local outbreaks of more serious damage, and a second species, *Lygus elisus,* is reported as being an important pest in parts of California and Arizona since about 1913. The occurrence of the other two species as major pests of cotton has, however, been noted only within the past few years, although one of them, the tarnished plant bug *(Lygus pratensis)* is a well known species of wide distribution and has long been recognized as a pest of various other cultivated plants.

The fourth member of the group, *Psallus seriatus,* was also known to be widely distributed throughout and beyond the cotton belt, but so far as has been found the earlier literature of cotton insects contains only one note (1) on its probable occurrence as a cotton pest. The recent developments of its role as a major pest of this crop has, therefore, been most interesting. Hunter (2 und 3) states that local attention in Southern Texas had been attracted at intervals for a number of years to a peculiar disorder of the cotton plant, reaching a climax in 1923, when much damage developed in the southern counties. This year also, apparently for the first time, the same disorder occurred in other parts of the State. The following year, 1924, there was much less injury, but it was almost as wide spread in Texas, and, again for the first time, a similar trouble was reported from Georgia and South Carolina.

Reinhard (4) states that *Psallus* was known to have been present in Texas for many years, but the first complaints of noticeable injury were received in 1919, the trouble remaining localized, however, until 1923, when it became a serious problem in the original area as well as other sections of the State. The planters in South Texas had referred to the damage as being caused by a "cotton flea", but the actual connection of *Psallus seriatus* with the disorder was not definitely known, until the experiments reported by Hunter and by Reinhard had been carried out.

In 1925, reports of mild outbreaks from various scattered points in

---

*) In the originally infested area this species became commonly known as the cotton flea, and the second part of the name was added later to indicate somewhat better its entomological position. In general field parlance at the present time, particulary in talking with planters, the name "flea hopper" or simply "hopper" is often used indiscriminately in referring to other related species, since the damage is more or less similar in results.

Georgia, South Carolina and elsewhere were received, but in 1926 most severe damage in many large areas of the cotton belt occurred simultaneously and with almost explosive suddenness. This was well indicated by the deluge of frantic inquiries and appeals by mail, telephone and personal visits of planters at the Delta Laboratory of the Bureau of Entomology at Tallulah, Louisiana, and in response to which a number of emergency circulars were issued and distributed by the Laboratory.

An additional point of special interest during the same year was the first recorded occurrence (5) in serious numbers on cotton of tarnished plant bug. This occurred in the Louisiana and Mississippi districts, and the insects were found not only in fields infested with flea hoppers, but also where *Psallus* was absent, and in certain of such fields it was to be noted that the damage caused by this species alone might be almost or quite as serious as that resulting from *Psallus*.

The typical and most important feature of the injury to the cotton plant caused by *Psallus seriatus* is the destruction of the very small flower buds or squares just as they emerge from the terminal clusters. These turn brown or black and later drop to the ground, leaving a distinct scar at the point of attachment.

A second characteristic and the one most readily oberved is an abnormal type of growth resulting from the injury. This may take one or more of several forms, the usual ones of which being the development of a long and spindly main stem and the production of extra branches from many of the nodes. If the terminal bud has been destroyed by the insects, one or two of the side branches may develop an excessive growth similar to the main stem, or, on the other hand, a clustering effect at the topmost nodes may occur due to the development of numerous shortened branches, with the result that the total height of the plant may be decidedly less than normal. This is particularly the case when the damage occurs while the cotton is very young. In addition to this, the destruction of tissue in the terminal cluster often produces very abnormal leaves, these being stunted in size and otherwise malformed.

A third feature of flea hopper infestation is the development of peculiar rounded or oval swellings on the stems, branches and leaf petioles. These are found on damaged field cotton and are particularly noticeable on caged plants on which numerous hoppers have been introduced. On an occasional stem or more usually leaf petiole and mid-rib where the feeding punctures have been numerous a continuous damaged area is found, having a roughened, corrugated appearance and with considerable destruction of tissue. On the individual swellings the epidermal layer may remain intact or, in more severe cases, will split open, exposing the sub-epidermal tissue, which soon dies and turns brown. Such local lesions often are visible for considerable periods after the insects have disappeared from the plants.

The injury produced by the tarnished plant bug has not been closely studied. So far as our observations go, the local lesions from feeding punctures on the stems and petioles are usually larger and more severe than those caused by *Psallus* and are therefore more readily found in the field. Splitting of the lesions appears to be more usual, and ugly looking wounds a half inch or even more in length and attributable to the punctures of this species are noticed occasionally. Furthermore, from a small number of

observations it appears probable that fruiting forms of a considerably larger size than those blasted by *Psallus* may commonly be attacked and destroyed and, as a matter of fact, in a recent experiment in which an excessive number of *Lygus* were introduced onto a large caged plant, shedding of large squares and even young bolls was produced.

A point of interest in this connection is the fact that the closely related species, *Lygus elisus*, is reported by McGregor (6) as destroying squares, blooms and bolls, but he is of the opinion that it does not attack any other part of the plant.

The loss of cotton from flea hopper infestation is naturally subject to much variation, depending upon the number of insects present, the length of time that the infestation lasts and quite probably a number of other factors. Hunter states that in South Texas in 1923 the loss was much greater than from the boll weevil and that in hundreds of fields no crop at all was produced. In 1924, with a much lighter general infestation, a field examined in July had only 765 bolls to 1000 plants. The more general experience, however, has been a very irregular distribution of damage in the fields and seldom with total destruction of the crop. Cotton is not the natural host plant of any of these species, and the fact that they turn their attention to it on occasions is undoubtedly associated with conditions affecting their more usual or preferred sources of food. Because of this only a very few instances have been noted in which the infestation remained on cotton throughout the season. It has been decidedly more usual for the infestations to last only a comparatively short time, so that in severe infestations the entire bottom part of the crop may be destroyed, but the top branches proceed with normal fruiting, since the plant recovers rapidly after the hoppers leave. In lighter infestations only a part of the early forms may be destroyed and an unusual feature of the damage in such cases is that distinctly abnormal "hopper plants" are found scattered about in a field, but surrounded by totally normal and undamaged plants.

Another and perhaps one of the most important sources of loss is the combination of boll weevil damage following the flea hopper attack. Under ordinary boll weevil conditions the planter often depends upon the early part of the crop maturing before the weevils become numerous, and a nearly normal amount of cotton may be produced, if no more than average weevil infestation follows. However, if the early bolls have already been much reduced by flea hoppers, the problem of producing the crop and combating the boll weevil becomes a doubly serious one.

References.

1. Howard, L. O.; U. S. Dept. Agr. Div. Ent. Bul. (N.S.) 18, p. 101, 1898.
2. Hunter, W. D.; Journ. Econ. Ent., Vol. 17, p. 604, 1924.
3. —; U. S. Dept. Agri. Cir. 361, 1926.
4. Reinhard, H. J.; Tex. Agr. Exp. Sta. Bul. 339, 1926.
5. Field circular issued by Div. Cotton Insects Investigations, U. S. Bureau of Entomology, July 5, 1926.
6. McGregor, E. A.: U. S. Dept. Agr. Tec. Bul. 4, 1927.

The Black Locust-Tree-Scale, Lecanium robiniarum Dougl., and the European Corn Borer, Pyrausta nubilalis Hübn., a Biological Parallel.

J. Jablonowski, Chief of the State Entomological Station, Budapest, Hungary.

It is a well-known fact that the best principle in the control of injurious animals is the prevention of their introduction in all cases where they have not yet occurred.

This object may be attained a) by prohibiting the importation of plants infested with injurious insects; b) by a general embargo; c) by quarantine proceedings within a suspected section of the country; d) by special instruction to inspectors; e) by instructive advice to raisers and growers with regard to the injurious insects under consideration, their economical importance, and, if possible, also with regard to their control.

Such is the viewpoint of today. But there is a wide secret gate continually left open, which heretofore never has been mentioned and consequently has remained unobserved.

What has been done up to the present time was to keep the road to the plant (plants of economical value only) closed for the insect pest in question, as far as could safely be done by human interference, in order that this insect pest might be unable to reach and infest the plant. But what will happen if, on the other hand, a new plant from another country is made available for the attacks of the injurious insect? Furthermore, if a different plant is attacked by an insect heretofore never considered of economical importance, but described on the one hand as a wellknown species and on the other entirely ignored from an agricultural point of view?

In speaking of insects, we speak of injurious, of useful, and of such other insects as are looked upon as indifferent and are classified in neither of the two former categories. We never speak of insects which may possibly become dangerous, of which no scientist is able to say that they may become dangerous tomorrow — or after a hundred years; that they may become injurious to plants of which nobody happens to think at the present, especially if the insects and their future host-plants are at present living widely distant — say, one on the American and the other on the European continent; or, if at some time in the distant future the insect and plant are brought together, the former to the disadvantage of the latter, that they may enter into a continuously antagonistic relationship. Such possibilities of damage are, of course, not discussed at the present time, because nobody raises any suspicion in the direction of possible

injurious qualities on the part of the insect. This may happen, some time later, as sad experience has taught.

You, dear colleagues of the United States, know very well that the potato beetle *(Leptinotarsa decemlineata* Say) is not indigenous in the country where the valuable potato *(Solanum tuberosum)* grew, and as long as this plant was not brought into the vicinity of the beetle, it got along very nicely on wild-growing *Solanaceae*, which it found in great abundance. But when the utility plant — our present potato — reached the habitat of this heretofore harmless beetle, our beetle, which we may call "Saulus," became suddenly a "Paulus," and we are aware of what that means for us today.

These are facts, interesting in a way, and offering plenty of opportunity to a far-reaching entomological brain to survey the endless variety of possibilities. We also must come to the conclusion that we are unable to get very far in this regard.

Supposing a danger is threatening us from that direction in the future, we shall be unable to do the slightest thing *a priori* in regard to it. Even though this may be so, I should like to call your attention to conditions based upon the experience we have had in this connection, namely, that an ordinary insect, which may be looked upon today as indifferent, is liable to become an injurious insect of great economic importance tomorrow, or it may migrate to other plants in such quantities that this phenomenon cannot remain unnoticed and its importance must be well considered.

I should like to refer only to two cases which we have in Hungary: namely, the scale we have on the black locust tree *(Robinia pseudo-acacia)*, and the European corn borer on corn *(Zea mais)*.

This question is so instructive and of such great importance that it is worth while to look into it more closely. It is an historical fact that the black locust *(Robinia pseudo-acacia)* is of American origin and that it has been carried from the United States to Europe and introduced to practically all other countries of the world. Many of the older generation of us have seen the living specimen of *Robinia* which was introduced first into Europe and planted in the Jardin des Plantes, and was safeguarded from total destruction, owing to great age, by hoops and iron reinforcement. Whether this old tree-veteran is still in existence, I do not know.

This type of tree, which originated in the United States, is today, after a period of nearly two hundred years, distributed all over the world, is very common in all countries where it has become acclimatized, and is known by everybody. This tree is of first-class economical importance to Hungary. Apart from cold, wet localities, it grows excellently in almost any soil and situation, and develops very rapidly. In 25 to 30 years its development shows practically all good qualities that we may expect from a tree of economical importance. Its timber is good for building and other industrial purposes, and also for fuel. As fuel it is first class, as it will burn very readily almost the moment it is cut, whereas other trees need drying for almost a year.

It is certain that after the deforestation of the Hungarian lowlands by cutting all oaks, all Hungary would be without any wood if it were

not for the rapid growth and excellent development of the black locust, especially since the Trianon incident in 1920, whereby Hungary was compelled in the treaty of peace to surrender to her neighbors all her magnificent forests in the North and East. It is undeniable that this tree has been a great help to Hungary before the country's mutilation.

In Hungary, this useful tree was generally known — up to the end of the last century, say, 1870-1880 — to be free from any animal or vegetable parasite; at least, it was not affected to any alarming degree. The caterpillar *Zeuzera aesculi* (= *pyrina)* was once in a while found boring in the trunk or larger branches, but the occurrence of this moth was rare and of scarcely any importance.

At the beginning of the 80's in the last century, attention of the forest wardens was called, especially in the vicinity of Budapest and Szeged, to the fact that *Robinia* was severely infested by coccids; that is to say, to such an extent that the Administration of Forests considered the matter as quite serious. Conditions in the vicinity of Szeged were particularly bad and a young forest officer by the name of Francis Kiss, who investigated the matter and studied the situation more closely, judged the infestation of *Robinia* in that section as very dangerous.

It was soon reported that *Robinia* not only was severely attacked by this coccid, but that the latter also inflicted serious damage to entire tracts of *Robinia*, which were dying. Dr. Géza Horváth studied this coccid very closely in the 80's. He found that is was a new species for Hungary and he sent specimens of the species to Mr. Douglas, a coccidologist of great reputation in England. Mr. Douglas declared the insect to be a new species and described it in the Entomologist's Monthly Magazine (London) under the name of *Lecanium robiniarum* n. sp. Dr. Horváth then studied the biology of this coccid and published his observations in the Reviews of the Hungarian Academy of Sciences.

There was, besides, a committee of forest wardens and forest entomologist under the direction of Doctor Horváth which studied this question for several years from the viewpoint of its economical importance, and which made investigations of all new infestations. Later it was found that the situation was not quite so tragic as it was depicted. A few trees were found dying, but not because of infestation by this coccid, but rather on account of the poor soil on which they grew, which was unfavorable for their development. This was the case in wet, swampy, stony soil and in the re-afforestations where cuttings were used in place of rooted plants from the forest nursery. It was also shown that the trees in question suffered of chlorose, and that such trees were usually found free from infestation. The cause of their disease had nothing to do with the coccid of which I spoke, but was due to the condition of the chlorotic soil. The single Robinias which were found in cities, villages, or elsewhere frequently grew in front of houses in a very stony soil, usually on broken bricks and debris, sometimes also in the neighborhood of a sewage outlet in which dung water or the dishwater from kitchens, soapy solutions from laundries, etc., were flowing in the old-fashioned way. No wonder that, under these circumstances, the foliage of these trees turned prematurely yellow and the leaves dropped.

A single, but actually disadvantageous, phenomenon could be noticed on infested trees, which evidently is due to the infestation; namely, that the trees infested by the coccids were later in sprouting as compared with other, healthy, locust trees which had little sprouts, although this type of tree generally opens its buds at a later date than most of our deciduous trees.

Was this loss in time a disadvantage? Not always. Sometimes it turned out to be even beneficial. In case of a severe frost in spring, which sometimes occurs with us during the first half of May, when a sharp frost (black frost) actually destroyed all that was green and turned it black, so that it had the appearance of having been burnt, the locust trees retarded on account of the infestation by coccids were saved, much to the satisfaction of the beekeepers of Hungary. It may be said that *Robinia* in favorable years is a very valuable honey plant. — What was first considered to be a disadvantage caused by the coccids, was soon found out to be a decided advantage, which under these circumstances may sometimes assume a certain degree of economic importance.

At the end of the last century one began to see clearly in Hungary that *Robinia* (also known by its Latin name *Robinia nostras*, given to this tree in Hungary over 200 years ago) is not endangered by the infestation of the coccid in question. This tree, however, will be more appreciated in the future and should be reared with greater care on an increasing scale.

At the beginning of the 90's of the last century, Dr. Paul Marchal of Paris ascertained that *Lecanium robiniarum* Dougl., which also occurs in France, was no new species at all and that it was identical with the *Lecanium (Coccus) corni* Bouché. Marchal's further investigations and experiments showed that *L. robiniarum* was nothing but a large growing form of *corni* and that this scale migrated from *Cornus* and assumed the larger type of *Lecanium robiniarum* Dougl. He also ascertained that this smaller type can easily be transferred from *Cornus* to *Robinia* and that it will develop on the latter tree to the large size type. It is this species of insect which Marchal correctly identified and to which he gave the name *Eulecanium corni* (Bouché) var. *robiniarum* (Dougl.) Marchal. He described this coccid in the Annales de la Société Entomologique de France with a few others and gave an excellent account of the former coccid in his work. It is regrettable that Marchal did not extend his excellent work to all other coccids which occur in France.

From all I have stated before we may come to the following conclusion. The American *Robinia*, which, as far as I know, is free from any infestation by *Lecanium corni* in the United States, was infested in Europe, perhaps in Hungary or in France, by *Lecanium corni*, and this new *Robinia* coccid thus had evidently found a host plant more satisfactory than its former original host. It is safe to say that the original plant had been imported into Europe without infestation, because the coccid which infests it in Europe — although not in a dangerous way, — does not exist in the original home of the tree. It acquired this new parasite only in Europe. How would it be if this coccid had turned out to be dangerous to its new host? If the development of this useful tree would be materially handicapped by the infestation or even rendered

impossible? Who would be responsible for this outcome? Nobody could possibly have thought that some danger might arise in this way for a new importation.

Let us consider another point referring to the question of the corn borer. In this connection the situation is about as follows: It is a well-established fact that *Zea mais,* the corn of the Americans (Indian corn referring to the Indians in America and not to the East Indians in India), is of American origin and was introduced at some time, like the *Robinia,* in different ways into Europe, where it was soon distributed over the continent as a valuable foot plant, like the potato and others, and has become one of the most valued food plants in Southern Europe and other continents, wherever conditions prevailed which were favorable to its development.

Corn is also remarkable in that it has no parasite which is exclusively dependent on this particular plant, although it may be attacked, like the *Robinia,* by polyphagous insects. This plant had first to be brought to Europe, like the *Robinia,* and had to become acclimatized in its new environment, before it met its arch enemy in the shape of *Pyrausta nubilalis,* a moderately sized moth, which one hundred years ago (1837) was described by Vincenz Kollar, of Vienna (Austria), and named "Hirsezünsler" (Millet moth), because he found its caterpillar to be injurious to millet. This moth was also frequently called hop moth *(lupulina, lupulinalis)* because it was also seen on hops. Some 40 to 45 years ago little attention was paid to the fact that in France it also attacked corn, as Laboulbène had pointed out. About 35 or 36 years ago I called the attention of the Hungarian farmers to the fact of a new danger threatening the corn (mais), but little attention was paid to my remarks at the time. (I should like to mention the fact here that Laboulbène's work was unknown to me at that time.)

It required that *Pyrausta nubilalis,* after it had become an established pest to corn and closely allied plants in Europe, had first to be brought to the original home of the corn plant — possibly on a plant heretofore entirely ignored or not suspected, perhaps broom corn or hemp — in order to migrate in its new environment over to corn.

This case of transmission is very much like the case of the *Robinia,* the only difference being that the United States have yet to wait for the importation of the *Robinia* coccid.

The case of the European corn borer deserves to be further stressed for this reason that, while corn *(Zea mais)* had its original home on the American continent and is attacked in Europe by *Pyrausta nubilalis,* it has become a dangerously injurious insect of great economic importance and adapted itself slowly but gradually to the corn plant in Europe.

The European corn borer was not introduced into the United States on ear corn or food corn proper, but on broom corn, or perhaps with hemp. The European corn borer made its entry into the United States on one of these two plants in an unobserved and unsuspected manner at a time during the Great War (1917) or somewhat earlier, when no entomological eye spied on it, when no embargo existed for it, when no cyanide or arsenic and no spray of any kind blocked its way, and last but not least when no airplane strew any poisonous dust on it.

We do not know of course for sure which was the proper host plant of this moth in Europe before it attacked the corn. We were aware of the fact that the caterpillar lived, besides on millet *(Panicum)*, on hemp and hops. It is, therefore, more than probable that it was well established in Europe before it became a pest to the European corn. Our native weeds seem to be fairly exempt from any attacks by *Pyrausta nubilalis*. Although the caterpillar may be found once in a long while on wild growing *Artemisia* (which is a great rarity in Hungary), the situation in general is not as dangerous with us as it is in the United States, where, I think, more than 200 different plants and weeds are enumerated as serving as host to the corn borer.

I presume, based upon my knowledge and experience in my own native country, that the European food plant of *Pyrausta nubilalis* properly so-called is the hop, a perennial, which by its lasting existence renders life more easily possible to this injurious insect (the development of which in Europe takes one year with hibernation) than annual plants would do, such as the hemp or the millet, which are more or less entirely consumed or destroyed after their useful parts have been harvested. The destruction of stem, roots and the rest of these plants would render the living conditions of the caterpillars and pupae hibernating in the stems or roots of these plants in all probability 100% more difficult.

My assumption that hop is the original food plant of *Pyrausta nubilalis* is also confirmed by the fact that hop grows in Central Europe in a semiwild state, is very common, and develops best in sections where conditions are also favorable for the cultivation of corn. The corn borer made a modest living on, or rather in, this plant for some time past and still is doing so at present, and I must say it is practically unnoticed, except by a scrutinizing entomological eye. It is not considered to be a dangerous pest to hops, although it lives in this plant in exactly the same way as it does in corn. Also its attack on corn in Hungary is not heeded by farmers so long as the attack is moderate, say 3 or 5 caterpillars to a plant. In such a case no farmer in Hungary will speak of it as a dangerous pest to corn, provided no ears or ear petioles have been injured.

The same may be said in the case of rational management of hop cultivation, where all hop waste is carefully collected every year and thoroughly destroyed. The consequence of this system is that the possibility of any dangerous increase of the moth in question is well nigh eliminated.

I see in these points the reason why the original food plant of the corn borer in Europe should be looked for in the hop.

If we review the question, I am of the opinion that we might reply as follows:

Nobody knows, and nobody ever will know, what plant may eventually be endangered by some kind of animal and where. For nobody knows nor is able to know the distribution which a plant of economic importance is likely to assume in our present civilization, and in which direction it will travel on the routes unobstructed at the present time. This may mean as much as to say that we are practically powerless in this regard. But it is not entirely so. I agree that no human laws, no embargo, no quarantine, no prohibition, etc., will be of any help in this

regard, but one thing is sure to be of great assistance and this is Agricultural Entomological Science.

The agricultural entomological science of to-day is no old-fashioned school knowledge, but it is a white-hot science, forged hard by new scientific discoveries on the anvil of experience, where sparks of life and energy are flying in all directions.

I am not speaking of puzzles. I remember, for instance, the hard battle we had with *Phylloxera,* which we fought successfully in Europe under conditions similar to those described above.

This insect, *Phylloxera vastatrix* Pl., travelled about the same way as the two insects of which I have spoken. It was shipped to Europe not on *Vitis vinifera,* but very likely on a hybrid of *Vitis riparia* or some other American species. Once in Europe, it waited patiently till it almost succeeded in preventing the drinking of wine in Europe in a much easier way than your American law of prohibition ever will accomplish with all the jail punishments and fines connected with it. Until the last of his species has died out, Homo sapiens will always find some ways and means in his clever Sapientia, to remain a Homo vinum bibens in spite of the laws of teetotal sagacity.

Well, this insect-power, alias *Phylloxera,* which threatened the drinking of wine, was far from reaching its goal. It saved the infested European grape vine in a new manner, in an agricultural way. A life-science opened to man a road, after some very hard work and sweat of brow, and showed him how he will be able to realize his ambition in the future, although it may not always involve the drinking of wine.

Such will be the consequences in future, while our utility plants are shipped all over the world, and are threatened and possibly attacked in the same way, as it has been up to the present time with the potato beetle, the grape phylloxera, the black locust scale, the corn borer and others. There are indications that we shall have a similar experience with the Painted Lady Butterfly *(Pyrameis cardui),* since this species shows at the present time a decided inclination to change from a weed destroyer frequently considered useful into an important pest of Lupine. The caterpillar of the Painted Lady is little concerned about any botanical relationship between Lupine and the field thistle *(Cirsium),* just as little as the corn borer cared when it changed its habitual diet from hops to corn, which evidently suited it better.

To conclude, I would like to say there are no limits to agricultural entomology, if this branch of science will follow genuine biological principles. I assume that to-day every scientifically trained field entomologist will work exclusively in this direction. This science has met with new phenomena and always will meet with such, as long as organic life will exist on this globe. So long as man is obliged to derive part of his food supply from the vegetable kingdom, and so long as there is an actual struggle for existence between the vegetable kingdom and the insect world, so long will field entomology be called upon to find new ways, means and weapons, to cope with the situation in an adequate manner.

The field entomologist, whom we also call applied entomologist, must be competent in the realm of his work. He must be a good up-to-

date biologist; *pro primo*, he must have a thorough knowledge of that class of animals which is intimately connected with his daily profession; *pro secundo*, he must be well posted in the outer and inner life of those plants of economic importance the life of which he is destined to safeguard; and *pro tertio*, he should be well acquainted with agricultural methods of cultivation and industry and their objects. He will be able to answer questions intelligently and to the point, when he realizes the responsibility connected with his profession, and prepares himself for it in an adequate manner. He will then also be able to solve similar questions as the ones I have cited as examples, i. e., concerning the corn borer and the black locust scale.

If the younger generation in entomology will follow the advice given here, I am convinced that it will become an established fact that all injuries by animals (insects) are nothing but the effects of our rapidly progressing civilization. They represent in a certain way a kind of whipping device in the progressing world culture, because they force the agriculturist to systematized work with a well-defined object, the control of injurious animals becoming in consequence automatically his life rule. I hold that this will always remain the most beautiful and noblest object in the life of a scientific man.

Klima und Seuchen vom Standpunkte des Entomologen.

Dr. E. Martini,
Institut für Schiffs- und Tropenkrankheiten, Hamburg, Deutschland.

(Mit 2 Textfiguren.)

Die Insekten sind eine Großmacht. Das Chitin gestattet ihnen nicht nur, unsere Kulturen und Vorräte mit scharfen Mandibeln zu benagen, sondern, was uns viel direkter schadet, durch die Bildung feiner Kanülen unser Blut zu saugen und Krankheiten auf uns zu übertragen. Es gestattet den Insekten, den Menschen überall hin zu folgen und ihm die Weltherrschaft streitig zu machen.

„Mosquito or man", so hat man den Schlachtruf um die Weltherrschaft gefaßt, dabei wohl in erster Linie der Malaria gedenkend, die gerade in den produktionsfähigsten Zonen große Gebiete der menschlichen Kultur unzugänglich machte und allein in Indien jährlich Millionen Menschenleben fordert.

Keine Absonderlichkeit in der Pathologie ist die Beziehung: Mensch-Malaria-Anopheles. Über 20 Leiden des Menschen werden ausschließlich oder doch sehr wesentlich durch Insekten ausgebreitet. Das ist aber keine Spezialität der Insekten. Ganz Paralleles tun die Arachnoiden. So wird z. B. der gewöhnliche Flecktyphus von Pediculiden, der Rocky Mountain-Flecktyphus von Ixodiden verbreitet. Auch Krebstiere, ja sogar Würmer, können Krankheitserreger übertragen. Die schlimmsten aber sind doch die Insekten.

Und der Mensch ist in diesem Unglück nicht allein. Seinen Haustieren fügen die Insekten gleiches Unheil zu. Auch von den wildlebenden Tieren empfangen viele durch Insekten die Keime schwerer Krankheit und fast für jede besondere Form von Krankheitsübertragung durch Insekten in der Zoopathologie läßt sich in der Phytopathologie eine Parallele finden.

Umfassend und großartig wie als züchtende Gärtner im Reiche der Blütenpflanzen wirken sich die Insekten als jätende und beschneidende Gärtner mit Hilfe der Seuchen in den beiden großen Reichen des Lebens aus.

Doch allmächtig sind die Insekten nicht. Schranken setzt ihnen vor allem das Klima. Man klagt oft, Flora und Fauna des Nordens seien arm. Wir sollten uns darüber freuen. Gehören doch die Erreger und Überträger der Seuchen großenteils zur klimatisch bedingten Flora und Fauna.

Es ist ein Glück, daß die furchtbare Schlafkrankheit auf das warme Afrika begrenzt ist. Die Trypanosomen, welche diese Krankheit erzeugen und im Blut zwischen den roten Blutkörperchen leben, werden bekanntlich durch Glossinen übertragen. Die Glossinen sind auf heißes Klima mit schat-

tender Vegetation beschränkt. Entsprechend kommen sie in der gegenwärtigen Erdepoche aus Afrika kaum heraus, und ebenso geht es nicht nur der menschlichen Schlafkrankheit, sondern auch vielen von Glossinen verbreiteten Tiertrypanosomiasen, z. B. der Nagana, während die von Tabaniden verbreitete Surra, eine Trypanosomiasis der Rinder, Pferde und Kamele, ein ungeheures Verbreitungsgebiet in der alten Welt hat.

Wenn die Chagas'sche Krankheit, deren Erreger auch ein *Trypanosoma* ist, *Schizotrypanum cruzi*, durch die Cimiciden übertragen würde, würde sie wohl längst rund um den Globus verbreitet sein. In der Tat hält sich das *Schizotrypanum* wie so viele andere Krankheitserreger lange in den Cimiciden, und wenn man einen solchen infizierten *Cimex* mit Kochsalzlösung verreibt und einem Versuchstier einspritzt, wird es krank. Aber die Natur spritzt nicht mit Insektenbrei, in Wirklichkeit scheint der *Cimex* weder in diesen noch in anderen Fällen eine gefährliche Rolle zu spielen. Durch den Stich selbst überträgt er in der Regel nicht, da er nicht erbricht, und den Kot setzt er meist nicht während des Saugens ab. Letzteres aber tun gerade die großen Triatomen und bringen so die Trypanosomen auf die angefeuchtete Haut. Die Triatomen aber sind auf die warmen Länder beschränkt und reisen nicht auf Schiffen. So entscheidet ein kleiner physiologischer Unterschied bei den Hemipteren über Gesundheit und Krankheit zahlloser Menschen, und über die Grenzen, die das Klima der Seuche ziehen kann.

Würde der Flecktyphus genau so gut von Kopfläusen wie von Kleiderläusen ausgebreitet, so würde er auch die wärmsten Klimate nicht verschonen. Wohl geht *Pediculus humanus capitis* leicht von Mensch zu Mensch, aber nicht leicht genug für die Anforderungen der Seuche. *Pediculus humanus corporis* gedeiht aber bei großer Hitze in leichter, von Licht durchdrungener, oft gewechselter Kleidung nicht. Daher sind Flecktyphus-Epidemien häufig bei unzivilisierten Völkern und Verwahrlosten der *gemäßigten* und *kühlen* Länder oder auf den Hochebenen, z. B. der mexikanischen Ebene, während er dort an der Küste fast fehlt. Sie sehen hier, wie die bionomischen Unterschiede zweier Subspezies dem Klima erlauben, die Seuche zu umgrenzen.

Und wie das Fleckfieber verhält sich anscheinend das Fünftagefieber, das auch durch sogenannte Rickettsien erzeugt und durch Kleiderläuse übertragen wird.

Der dritte von diesen pediculophilen Seuchenerregern ist der des gemeinen Rückfallfiebers, die *Spirochaeta recurrentis*. Auch dieses Fieber ist eine Krankheit mehr gemäßigter und kühler Länder. Die leichteren Rückfallfieber der heißen Länder werden durch Zecken, nämlich die *Ornithodorus*-Arten dieser Länder, verbreitet. Die ihnen nahe verwandten *Argas*-Arten plagen auch manche Tiere mit Spirochaetenkrankheiten.

Kleinere Beulenpestepidemien treten noch ziemlich weit polwärts von den Wendekreisen auf, aber die großen städtischen Epidemien beschränken sich heutzutage überwiegend auf recht warme Gebiete. Man nimmt ja an, daß diese Epidemien sich stets auf dem Boden umfänglichen Rattensterbens an Pest entwickeln. Haben nun auch die neuen Untersuchungen von Hirst wie die alten von Verjbitzki die Auffassung gereift, daß jeder Floh unter geeigneten Umständen Pest von Tier zu Tier übertragen könnte, so hat doch kürzlich Hirst die Anschauung von Cragg bestä-

tigt, daß bei weitem am leichtesten *Xenopsylla cheopis* die Pest von den Ratten zum Menschen bringt. Daß dies eine wärmeliebende Flohart ist, ist einer der Gründe für die heutige relative Immunität der kühleren Gegenden gegen menschliche Beulenpest. Es war ein großes Glück, daß in der Zeit, als Simond und Ogata die Bedeutung der Flöhe für die Pest feststellten, die Systematik dieser Gruppe durch Jordan und Rothschild schon weit gefördert war. Ein Beispiel, wie jede wissenschaftliche Forschung, mag dem Laien die Geldaufwendung für seltene Flöhe auch noch so spaßig erscheinen, plötzlich einen ungeheuren praktischen Wert erlangen kann, eine Mahnung an kurzsichtige Maecene und Verwaltungen!

Die *Leishmania donovani* befallen überwiegend die Eingeweide und verursachen große Sterblichkeit: Kala-Azar. *L. tropica* dagegen erzeugt eine viel harmlosere, überwiegend die Haut entstellende Seuche: Orientbeule. Beide gehören nur wärmeren Ländern an. Das scheint heute aufgeklärt, hält man doch nach den Untersuchungen von Sergent, Adler und Theodor, sowie Knowles, Napier und Smith u. a. Phlebotomen für die Überträger, und die Phlebotomen gehören ja zur Fauna der warmen Länder.

Das Pappatacifieber verbreitet sich oft explosionsartig auf den Flügeln der Phlebotomen und ist entsprechend ein Fieber, und zwar ein gutartiges, warmer Länder.

Das Denguefieber folgt mit der Nordgrenze seiner Epidemien ziemlich der Nordgrenze der Stegomyienverbreitung.

Andere Seuchen verhalten sich aber in dieser Hinsicht dem Norden gegenüber viel zurückhaltender.

Auch der Erreger einer Seuche, nicht nur der Überträger, bestimmt nämlich die Seuchenverbreitung. Krankheitskeime, die durch Kontakt im engsten Sinne von Mensch zu Mensch oder von einem warmblütigen Tier zum anderen weitergegeben werden (z. B. Trichinen, Syphiliserreger) haben dauernd die gleiche nähere Umwelt von recht konstanten Bedingungen. Ein Erreger aber, der, um sein Ziel zu erreichen, auf ein wechselwarmes Tier umsteigen muß, bekommt auf diesem Transport die klimatischen Verhältnisse der weiteren Umwelt zu spüren.

Der Gelbfiebererreger scheint sich unter 20° C nicht in der *Stegomyia* entwickeln zu können. Daher ist das gelbe Fieber nur in warmen Gegenden und Jahreszeiten ansteckend. Bei dem Malariaerreger liegt diese Grenze der Entwicklungsfähigkeit nach Jancso bei ungefähr 16—17° C und ihre Endemiegebiete überschreiten fast nirgends die 15° Sommerisotherme. Daß die Anophelen der kühleren Gebiete gerne warme Ruheplätze aufsuchen, ist dabei ein für die Malariaansteckung wichtiger Faktor.

Filaria bancrofti würde Überträger wohl noch bis zum 65. Grad n. Br. finden. Da sie aber zur Entwicklung in der Mücke hohe Wärme braucht, sind autochthone Infektionen in Europa kaum bis über den 40. Breitenkreis bekannt.

Ähnlich dürfte es mit *Filaria loa* sich verhalten, deren Übertragung durch *Chrysops*-Arten besonders Connal und Connal studiert haben, oder mit *Filaria perstans*, die wohl auch unter anderen *Culicoides* weitere Überträger finden würde, als den afrikanischen *C. austeni*, der nach Sharp's Untersuchung Zwischenwirt ist. Von den Onchocercen (Blacklock) übertragen durch Simuliden (bisher *O. damnosum* allein bekannt),

und den Hundefilarien, gilt wohl dasselbe, daß es für sie alle noch geeignete Überträger weit außerhalb ihres Verbreitungsgebietes gäbe, daß sie also in ihrer Verbreitung durch ihr eigenes Wärmebedürfnis begrenzt werden. Das gleiche betrifft *Dermatobia,* für deren Eier als Träger sich bis in den hohen Norden stechende und nicht stechende Fliegen, Mücken u. a. in großer Zahl finden würden.

So erklärt sich die geographische Beschränkung einer ganzen Flora und Fauna von Seuchen sehr einfach durch die Wärmeansprüche der Erreger und Überträger, aber auch sehr oberflächlich und für den schärferen Beobachter wenig befriedigend.

Meine Damen und Herren! Man hört manchmal als von einem Naturgesetz davon reden, daß die Häufigkeit jedes Lebewesens Null werde, es also fehlen müsse, wo ein notwendiger Faktor fehlt. Das ist kein Naturgesetz, sondern die Erklärung des Wortes notwendig. Die Beobachtung lehrt aber, dass Arten auch dann fehlen können, wenn jeder der einzelnen für sie notwendigen Faktoren gegeben ist, z. B. in einer Größe, die an irgend einem anderen Ort durchaus für die Existenz der btr. Art ausreicht. Es gibt also nicht nur kritische Werte der Umweltfaktoren, bei denen oder jenseits derer eine Spezies überhaupt nicht mehr vorwärts kommen kann, z. B. Stegomyienwert 0 für Gelbfieber, Temperatur von 16° oder weniger für Malariakeime, sondern auch Schwellenwerte, die über dem kritischen Wert, aber je nach Gestaltung der übrigen Umweltfaktoren verschieden hoch liegen, unterhalb derer sie also blos unter den übrigen gegebenen Umständen existenzunfähig ist.

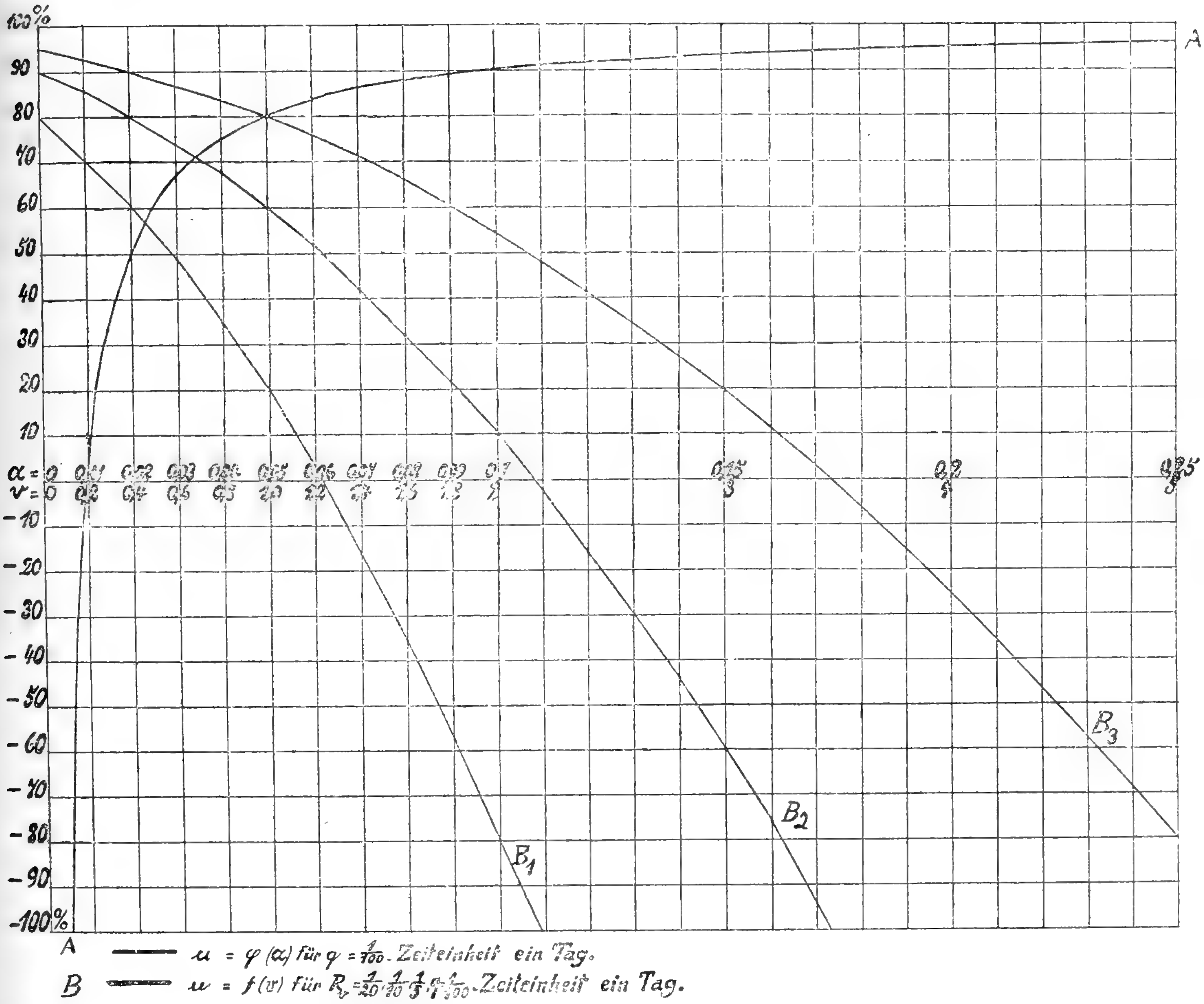
Hier sind wir an eine ganz böse Ecke gekommen. Es ist die Abhängigkeit einer Erscheinung gleichzeitig von mehreren Variabeln. Die Sache ist am besten auf dem Malariagebiet durchgearbeitet, wo Ronald Ross bereits voranging, Lotka, Sella, ich selbst u. a. weiter gearbeitet haben.

Die Formel der Malaria, nach Möglichkeit vereinfacht, kann geschrieben werden $u = 1 - \frac{q}{\alpha}$ oder für unsere Zwecke, indem wir die Zusammensetzung von x aus der relativen Mückenzahl dem Viehfaktor und den Rest der andern Faktoren berücksichtigen, $u = 1 - \frac{q}{m(1+v)^{-2} \cdot R}$. In dieser Formel bedeutet u den infizierten Bruchteil der Bevölkerung; q den durchschnittlichen Teil der Erkrankten, der in der Zeiteinheit geheilt wird; m die *Anopheles*-Zahl pro Kopf der Bevölkerung, v den Viehfaktor und R die übrigen malariogenen Einflüsse außerhalb des Menschen. Von diesen Faktoren ist m vor allen vom Klima abhängig, das durch Niederschläge die Größe der einzelnen Bruten und durch die Wärme die Zahl der Bruten im Jahre regelt.

Ausführlicher: u bedeutet den Teil einer Bevölkerung, der von Malaria verseucht ist, d. h. Malariaplasmodien im Leibe hat, z. B. $\frac{78}{100}$ in einem stark verseuchten Gebiete. Von diesen Leuten sind viele krank, andere aber, die Mehrzahl, scheinbar ganz gesund oder ziemlich gesund. Letztere nennt man die gesunden Keimträger. Diese Gruppe ist für das Verständnis vieler Seuchen äußerst wichtig. Solche Keimträger erkranken nicht, wenn sie von infektiösen Mücken die gleiche Art Malariaparasiten erhalten, die

schon in ihnen leben. Denn ob zu ihren vielleicht 30 000 Plasmodien eine Mücke noch 300 oder 1000 hinzuspuckt, ändert an dem biologischen Gleichgewicht zwischen ihrem Körper und den Parasiten nichts. Dieser Anteil u der Bevölkerung kann also Ausgang von Infektionen werden, wird aber selbst durch Superinfektion nicht beeinflußt. Die Gefährdung eines Menschen im Malariagebiet ist natürlich um so größer je mehr kranke Keimträger es gibt, ceteris paribus ist sie "u" proportional. Nennen wir den Proportionalitätsfaktor "α", so ist die Gefährdung des einzelnen im Malariagebiet in der Zeiteinheit "αu". Es stellt also "α" den gefährdeten Einfluß aller anderen Faktoren des betreffenden Gebietes dar, abgesehen

Bild 1.



von der Zahl und Beschaffenheit der infizierten Menschen, also die Einflüsse der *Anopheles*-Zahl (α ist ihr proportional), der *Anopheles*-Art, der Wärme und vieles andere. q bezeichnet den Bruchteil unter den Kranken und Keimträgern, der in der Zeiteinheit entweder ausheilt (d. h. Plasmodienfrei wird) oder sonst infolge Tod oder Geburt bzw. Ab- und Zuwanderung durch keimfreie ersetzt wird.

α ist wie gesagt der *Anopheles*-Zahl ceteris paribus proportional, ferner um so kleiner, je mehr Vieh vorhanden ist, eine Abhängigkeit, die sich durch den Wert $(1+v)^{-2}$ ausdrücken läßt. Als Einheit des Viehfaktors ist diejenige Menge Haustiere anzusehen, welche die Anophelen unter gleichen Bedingungen genau so stark anzieht, wie ein Mensch. Das ist nach

den Untersuchungen von Bull und Reynolds ungefähr eine Ziege und ein Schaf. 3 Ziegen und 3 Schafe würden also den Viehfaktor 3 bedeuten, eine Kuh würde etwa den Viehfaktor 5 und ein Pferd ungefähr dem Faktor 5,5 gleichzusetzen sein. Die Abhängigkeiten von der Wärme und verschiedenen anderen Dingen können wir mathematisch nicht fassen. Deswegen wird bei unserer Untersuchung α nur in dem Mückenfaktor, die Funktion des Viehfaktors und einem Restfaktor aufgelöst:

$$\alpha = m(1 + v)^{-2} \cdot R.$$

Kurve A stellt die theoretische Zunahme der Malariaverseuchung einer Bevölkerung mit zunehmender Infektiosität, z. B. zunehmender Mückenzahl der α proportional angenommen werden kann) dar. Kurve B dagegen die theoretische Abnahme der Verseuchung mit zunehmender Viehzahl. q bedeutet den Anteil der Bevölkerung, der in der Zeit-Einheit von der Malaria frei wird. R_v die Gesamtheit der außer der Viehzahl die Infektiosität bestimmenden Faktoren (die negativen Werte lassen natürlich keine einfache Deutung zu, sind aber doch nicht wertlos).

Die beistehende Kurve drückt die gesetzliche Bezeichnung $u = 1 - \frac{q}{\alpha}$ aus, für $q = \frac{1}{100}$ hat α einen ziemlich grossen positiven Wert an der Stelle, wo $u = 0$ ist, also der Grenzwert der Malariamöglichkeit liegt. Genau entsprechend verläuft die Abhängigkeit von u von der *Anopheles*-Zahl. Die Abhängigkeit der Endemiedichte u vom Viehfaktor geben die anderen drei nach rechts abfallenden Kurven. Diese Bilder lehren, daß die Endemiedichte mit steigender Mückenzahl zunächst sehr rasch, dann langsamer, schließlich kaum noch steigt, daß sie dagegen mit zunehmender Viehzahl immer rascher fällt.

Die gemeinsame Auswirkung von Mücken- und Viehfaktoren soll Ihnen Bild 2 erläutern, indem die Höhe der Malariadichte wie die Höhenlinien einer Karte eingezeichnet sind, selbstverständlich schematisch auf Grund der Formel.

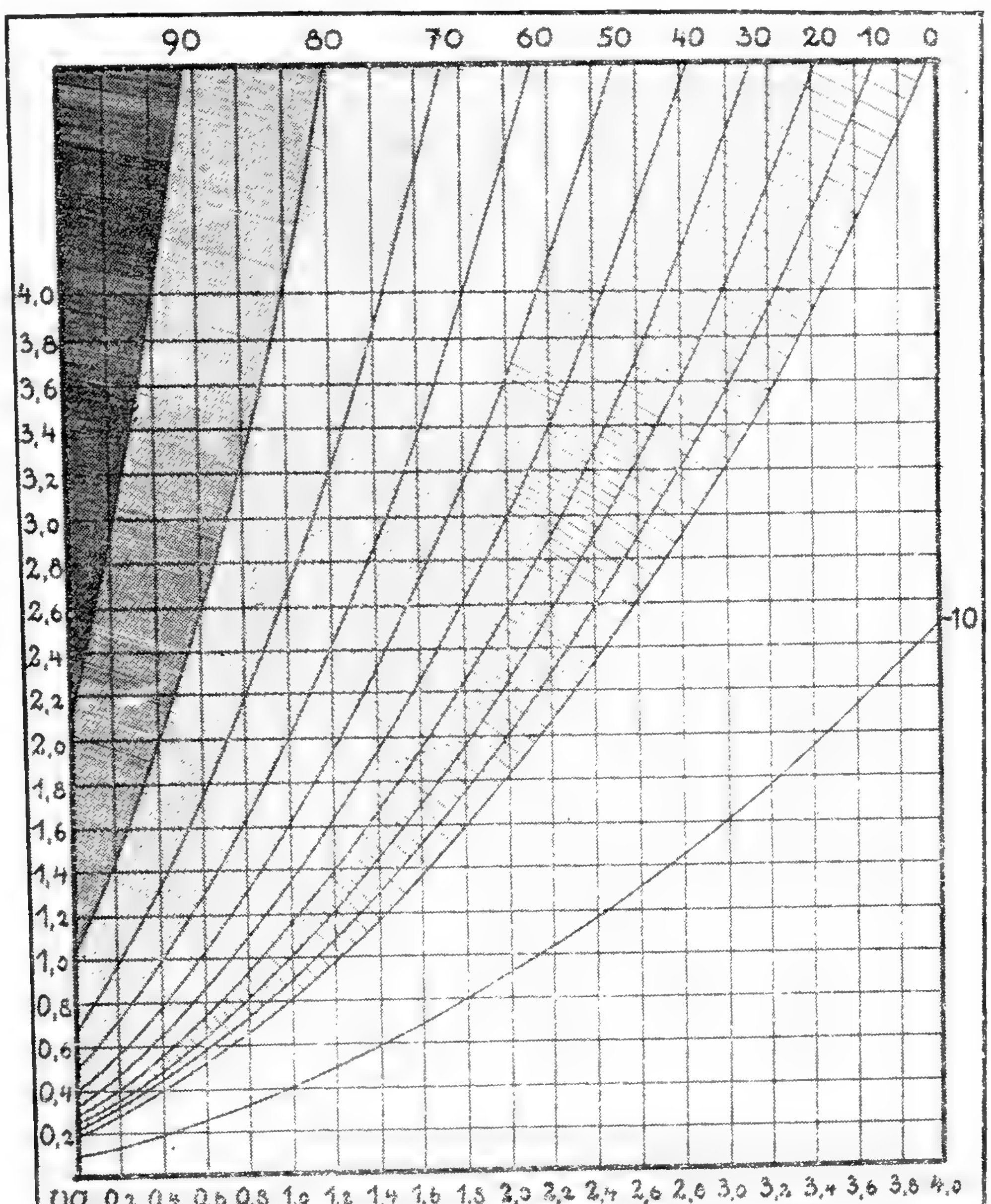
Die Grenze zwischen dem unschraffierten und schraffierten Felde ist die o-Linie des Malariaspiegels, je dunkler schraffiert, desto höher die Verseuchung bis über 95% links oben bei Viehfaktor annähernd gleich o und hoher Mückenzahl. Die Mückenzahl pro Kopf der Bevölkerung ist auf die Ordinate, der Viehwert auf die Abszisse eingetragen.

Sie sehen daraus, daß die Endemie beim Fehlen von Vieh (Viehfaktor = o) mit steigender Mückenzahl sehr rasch ansteigt, bei höheren Mückenzahlen sich aber kaum noch verändert, bei reichlich Vieh dagegen sehr viel langsamer steigt. Entsprechend muß auch die Zahl der Mücken, bei der zuerst Malaria endemisch auftreten kann, damit auch das Klima, bei viel Vieh sehr viel günstiger sein als bei weniger oder keinem Vieh, während umgekehrt bei viel Mücken der Viehfaktor schon recht groß sein kann, ohne daß Malaria auftritt, oder er bei wenig Mücken schon sehr klein sein muß, damit Malaria möglich wird. Es ist dies natürlich nur ein erläuterndes schematisches Beispiel, dessen Ausgestaltung im einzelnen auch von der Wahl der Faktoren q und R stark abhängt. Die absolute Grenze der Malaria würde erst bei dem Mückenfaktor o und bei dem Viehwert

— ∞ liegen. Zwischen diesen Werten und der Null-Linie unserer Figur liegt ein großes Feld, mit einem u kleiner als oder gleich 0, d. h. ein Feld, das Malariafreiheit bezeichnet. Dieses Feld gibt Ihnen, wenn Sie an die *Anopheles* denken, den Bereich des Anophelismus ohne Malaria. Er kann um so höher sein, je größer der Viehwert ist.

Nennt man krankheitsübertragende "nosophore" Insekten, so fordert die Theorie vom Unterschied kritischer gegenüber Schwellenwerten die Existenz eines Nosophorismus ohne zugehörige Seuche für alle durch Insekten verbreiteten Krankheiten. Das bestätigt denn auch bei genauer Be-

Bild 2.



trachtung ein Vergleich der Geographie all dieser Seuchen mit der ihrer Überträger. Das Gebiet des Nosophorismus ohne zugehörige Seuche wird um so größer, je schlechter der in ihm vorhandene Überträger ist. Anophelismus ohne Malaria ist also nur ein Spezialfall einer ganz allgemeinen Erscheinung.

Malaria k a n n e i n m a l selbst im Klima Schwedens übertragen werden, das bewiesen zwei neuerdings von therapeutischer Malaria ausgegangene autochthone Ansteckungen. E i n h e i m i s c h ist die Malaria bis auf wenige R e l i k t e und einen Herd im Mündungsgebiet des Rheins erst südlich der Alpen.

Eine bestimmte Isotherme begrenzt also nicht überall die Seuche, sondern ihre Grenze liegt vielfach weit zurückgezogen von der kritischen

Isotherme und die gleiche *Anopheles*-Zahl, die auf den deutschen Marschhöfen nur spärlich Malaria verursacht, führt im warmen Klima der deutschen Kaukasusdörfer zu schwerster Epidemie.

Denn auch die Parasiten entwickeln sich ja oberhalb der kritischen Temperatur nicht gleich optimal. Vielmehr ist die Entwicklung wenig über der kritischen Temperatur noch unsicher und langsam (bei 17° über 40 Tage), und wird mit steigender Temperatur immer besser. Im Experiment leben *Anopheles*-Weibchen leicht viel länger als 40 Tage. Im Freien aber ist für sie und viele ihrer Genossen der gewaltsame Tod der natürliche, und von 1000 *Anopheles* ♀ dürfte im Sommer kaum eines 40 Tage alt werden. Dauert aber bei 22° C die Entwicklung der Plasmodien in der Mücke nur noch 12 Tage, dann ist Aussicht, daß schon von 100 Anophelen eine Anzahl diesen Moment erleben, also infektionstüchtig werden.

Da wird mir vielleicht mancher denkende Zuhörer opponieren. Denn die Beschleunigung des Lebensablaufes durch die Temperatur gilt ja auch für die Anophelen. Sie verdauen rascher, reifen die Eier rascher, müssen in gleicher Zeit öfter zum Nahrungsuchen oder zum Brutplatz fliegen und sind also entsprechend auch mehr gefährdet, also kurzlebiger. Dieser Einwand wäre richtig, wenn die Abhängigkeit des Lebensablaufes der wechselwarmen Tiere der R. G. T.-Regel folgte, wie die einfachen chemischen Reaktionen, oder auch annäherungsweise, wenn die Temperatursummenregel von Pears und Blunk zurechtbestände. In Wirklichkeit zeigen alle solche Abhängigkeiten der Lebensprozesse von der Wärme ein Optimum, in dessen Nähe Temperaturänderungen wenig ausmachen, während etwas vom Optimum entfernt ihr Einfluß bedeutend ist. Fällt nun der Steilteil der Kurve für die Plasmodienentwicklung in die Temperaturen, die die Aktivität der Anophelen nur noch wenig erhöhen, dann sieht man leicht ein, daß die steigende Temperatur die Bedingungen der Plasmodien verbessern muß. Richtig ist aber doch etwas an dem Einwurf. Nicht nur die Lebensfähigkeit an sich des Überträgers bei einer bestimmten Temperatur, sondern auch die Lebensdauer des Imagolebens ist hier von Bedeutung.

Die Mortalität von *Anopheles maculipennis* erhöht sich z. B. nach James stark, sobald die Verhältnisse der Umgebung auch nur ein wenig tropisch werden. Bei Temperaturen, wo das *Plasmodium vivax* sein Optimum hat und *Pl. falciparum* dies noch nicht einmal erreicht hat, nimmt die Lebenszähigkeit von *A. maculipennis* so ab, daß die Ergebnisse der Übertragungsversuche dadurch schon verschlechtert werden und daß man praktisch 22 Centigrad nicht überschreitet.

In einem Lande, wo nur *A. maculipennis* zur Verfügung steht, können also besonders die Plasmodien der Tropica ihr Temperaturoptimum nicht ausnutzen. Aber in den heißeren Ländern treten natürlich für die Hitze resistentere Anophelen auf, so für *A. maculipennis* z. B. *A. sacharovi,* für *A. superpictus* der *A. sergenti,* und in ihnen wird dann das Wärmeoptimum auch der Tropica ausgenutzt. Hier sehen Sie wieder, wie die Epidemiologie die letzten Feinheiten der Systematik braucht, wenn sie den Tatsachen auf den Grund kommen will. Denn *A. maculipennis* ist von *A. sacharovi, A. superpictus* von *A. sergenti* nur schwer zu unterscheiden.

Es gibt sehr feine Beziehungen zwischen den Insekten und den von ihnen übertragenen Krankheiten. Es gilt der Satz: derjenige Überträger ist ceteris paribus für eine Seuche der günstigste, der die höchste Entfal-

tung seiner Leistungen d. h. große Aktivität und nicht zu große Mortalität bei den gleichen klimatischen Bedingungen hat wie der betreffende Krankheitserreger. Diesen Satz hat Hirst neuerdings für den *Bacillus pestis* und *Xenopsylla cheopis* sorgfältig erwiesen. Darum ist eben auch dieser Floh so hervorragend wichtig für die Pestausbreitung.

Die für die Epidemiologie der Tier- und Pflanzenseuchen so wichtige durchschnittliche Lebenslänge des Überträgers wird nun nicht nur durch die Wärme bestimmt; ehe wir auf andere klimatische Faktoren zu sprechen kommen, müssen ein paar Worte über die jahreszeitliche Verteilung der Seuchen gesagt werden. So ist der Flecktyphus meist vor allem eine Krankheit des ausgehenden Winters und des ersten Frühlings, weil in dieser Jahreszeit die Verlausung am stärksten zu sein pflegt. Das Pappatacifieber, auch das Denguefieber, sind typische Sommerkrankheiten, wenigstens in den kühleren Teilen ihrer Gebiete, weil die Phlebotomen nur im Sommer fliegen, und die Stegomyien im Sommer am häufigsten und am aktivsten sind. Auch die Parallelität im zeitlichen Auftreten der Ruhr und des Abdominal-Typhus mit dem der Fliegen, welche zweifellos diese Darmkrankheiten übertragen können, ist oft beachtet worden.

Warum wird das klassische Beispiel der Malaria nicht erwähnt? Wir wissen heute, daß vielleicht mehr als die sommerliche Aktivität der Mücken Besonderheiten der Plasmodien den jahreszeitlichen Gang der Malaria bestimmen.

Die Malaria tertiana kulminiert gewöhnlich im Frühjahr, ehe in ihrem kühleren Verbreitungsgebiet die für die Übertragung notwendigen Temperaturverhältnisse gegeben sind. Sie kulminiert etwa um dieselbe Zeit in Daenemark, in Schweden und in Italien. Sie bricht im Mai und Juni gelegentlich bei Truppen aus, die um die Zeit garnicht im Malariagebiet sind, wohl aber im Herbst vorher dort waren. Der Mai-Juni-Gipfel der *Tertiana* kommt also nicht von der Biologie der Mücken, sondern von der der Plasmodien, die eben um diese Zeit ihre Blütezeit haben. Die Ansteckungszeit liegt allerdings in den warmen mückenreichen Monaten. Aber nur in epidemieerzeugenden Jahren ergibt sich im August und September ein Tertianagipfel, dann aber stets in dem folgenden Epidemiejahr selbst ein viel höherer Frühjahrsgipfel. Warum blüht *Pl. vivax* im Mai-Juni?

Ich glaubte früher, daß es eine Anpassung sei, eine Bereitstellung reichen Parasitenmaterials für die Mückensaison. Ich sah darin eine gewisse Parallele zu biologischen Merkwürdigkeiten bei Filarien. Die Larven von *Filaria loa* nennt man Tagesfilarien, diurna, weil sie besonders tags in den Hauptkapillaren erscheinen, gerade zu der Zeit also, wenn ihr Überträger, die Tabanide *Chrysops*, aktiv ist, nachts sind sie in der Lunge. "Turnus". — *Culicidae*, besonders oft der nächtliche *C. fatigans* oder *Anopheles* übertragen *F. bancrofti*, ihre Larve tritt nachts im peripheren Blut auf, und bleibt am Tage in der Lunge, Mikrofilaria *nocturna*. In Gegenden aber, wo *F. bancrofti* auf die allzeit stechbereiten Stegomyien angewiesen sind, sind sie oft ohne Turnus, tags und nachts im Blute. Dem täglichen Turnus der Filarien könnte ja ein jährlicher der Plasmodien entsprechen mit Reichtum von Übertragungsformen zur Mückensaison. Die Annahme einer Blütezeit der Tropica (Subtertian Malaria) im Hochsommer reimte sich gut dazu. Aber, daß die Malaria Quartana im Oktober bis Dezember

blüht, läßt leider diese hübsche Theorie recht fraglich erscheinen.

Jedenfalls dürfen wir aber den Satz, daß jahreszeitlich auf den Gipfel der Überträgerhäufigkeit der Gipfel der Epidemie in kurzem Abstand folgen müsse, nicht als allgemeines theoretisches Postulat anerkennen, wenn er sich auch oft bewahrheitet. Rücksichtlich der Einflüsse der Jahreszeiten geht die Wirkung der meteorologischen Faktoren nicht immer über das übertragende Insekt, sondern manchmal auch direkt.

Meine Damen und Herren! Nun fangen wir wieder von vorn an beim Chitin. Es gibt eine noch fundamentalere Leistung des Chitins, als die mechanische, der wir schon Achtung und Mißfallen zollten. Wandert da am Fenster in der Sommersonne eine Fliege, eine Minute, fünf Minuten, eine Stunde. Das ist ein großes Wunder. Das Tierchen ist doch über die Hälfte Wasser und vertrocknet nicht, wo ein gleich großes Wassertröpfchen wohl kaum einige Minuten bestehen würde. Das Insekt ist eben durch das Chitin geschützt. Das ist eine kolossale Leistung: kann es für eine verdunstende Substanz eine ungeeignetere Form geben als etwa die eines Fliegenbeins oder Fliegenfühlers? Wie groß diese Schutzleistung des Chitins — NB. mit der lebenden Substanz zusammen — ist, wissen wir nicht. Krogh hat gefunden, daß das Chitin für Sauerstoff noch 6 mal weniger durchlässig ist, als Gummi. Die Sauerstoffundurchlässigkeit interessiert uns in diesem Zusammenhange nicht, obgleich wohl nur durch sie überhaupt Tracheenatmung ermöglicht wird. Wir können aber wohl eine entsprechende Undurchlässigkeit auch für Wasserdampf annehmen.

Das ist wohl die Grundbedeutung des Chitins. Jedoch! Die ursprünglichste Arthropodenklasse, die Crustaceen, brauchten ja gar keinen Verdunstungsschutz. Doch vielleicht! Die Triboliten in ihrem flachen Bau und ihrer Aufrollarbeit, die Gigantostraken mit ihrem Stachel, der ihnen sich umzuwenden erlaubt, wie den Molukkenkrebsen, zeigen wohl noch Organisationsmerkmale, die als Anpassungen an die Brandungs- und Gezeitenzonen gelten können. Brandungs- und Gezeitenzone dürfte der Lebensraum sein, wo das Chitin und ich möchte damit sagen: die Idee des Arthropoden entstanden sei.

Und dieser Verdunstungsschutz der Chitindecke, der gewissermaßen den Arthropodenstamm aus dem Schoße der Natur entbunden hat, ermöglichte Zweigen zum Leben ganz an der Luft überzugehen, und den Menschen zu begleiten, wo diesem sein stratum corneum zu exisfieren erlaubt, mit Wohltaten oder Missetaten. In der Gleichheit dieses Schutzes liegt begründet die Parallelität zwischen Arachnoiden und Insekten auf dem Gebiete der medizinischen Entomologie.

Aber so wunderbar die Leistungen des Chitins sind und so weltgestaltend seine Folgen in der Pracht der Blütenpflanzen und den Aberglauben oder Frömmigkeit weckenden Zügen wichtiger Seuchen sind, so hat die Leistung des Chitins doch ihre Grenzen, besonders bei Formen, die durch zierliche Gliederung sehr große Verdunstungsflächen bieten.

Für solche Formen bleibt oft trotz des Chitins Trocknung die große Gefahr. Eine Stechmücke z. B. stirbt in trockener Laboratoriumsluft meist innerhalb 24 Stunden. Aber auch für schwerer chitinisierte Formen ist die trocknende Kraft der Luft nicht unbedeutend. Bacot und Martin zeigen, wie bei gleicher Temperatur die Sterblichkeit des Pestflohes mit zuneh-

mender Trockenheit ansteigt. Die durchschnittliche Lebenslänge der Tiere fällt mit dem zunehmenden Sättigungsdefizit der Luft. Dagegen steigt bei gleichem Sättigungsdefizit die Sterblichkeit mit zunehmender Temperatur. Durch die in Indien vorkommenden Schwankungen des Sättigungsdefizits von 5—35 mm kann die Lebenslänge im Verhältnis 15:1 vermindert werden. Die Pest wird natürlich viel sicherer übertragen, wenn nach dem Pesttod ihres Wirtes die infizierten Flöhe etwa 30 Tage Zeit haben, einen frischen Wirt zu suchen, als wenn sie nur zwei Tage haben.

Neben der Wärme bestimmt nach Neave für die Glossinen die Luftfeuchtigkeit die geographische und die lokale Verbreitung. Nach ihren Ansprüchen an diesen Faktor ordnen sich die wichtigsten Glossinen z. B. folgendermaßen: *A. palpalis, pallidipes, morsitans.* Diese Ansprüche und die Verteilung der Blutspender bestimmen die jahreszeitliche Verschiedenheit der Verbreitung von *Glossina morsitans* im Norden und Osten Afrikas. Aus ihnen folgt die Bindung der von *Gl. palpalis* übertragenen westlichen Trypanosomenrasse an die Ufer der Flüsse und Seen, gegenüber einer größeren Verbreitungsfähigkeit der ostafrikanischen und nordafrikanischen Menschen- und Viehtrypanosomiasen, die infolge der stärkeren Anpassung von *Gl. morsitans* an Säugetierblut für die Viehzucht oft besonders verhängnisvoll wird.

Die Phlebotomen sind von dem Feuchtigkeitsfaktor auch nicht unabhängig, während das eigentliche Hausungeziefer anscheinend direkt wenig von ihm beeinflußt wird, ja z. T. offenbar eher gegen zu hohe Feuchtigkeit empfindlich ist.

Indirekt ist wohl die Wirkung der Trockenheit auf die Fliegenhäufigkeit. In den regenarmen heißen Zeiten der Subtropen mit großem Sättigungsdefizit der Luft trocknen alle pflanzlichen und tierischen Abfälle rasch und werden so schnell als Brutplätze für die Fliegenlarven unbrauchbar. Zwar haben die Fliegen wie *Calliphora* u. a. in außerordentlich hohem Maße die Fähigkeit, wenn den Larven der Nahrungsvorrat zu Ende geht, doch unter Bildung von Zwergformen die Entwicklung abzuschließen, vielleicht gerade als Anpassung, um der Vernichtung durch die Dürre zu entgehen. Aber die Zwergformen erzeugen nach Weidling viel weniger Eier und so ist die Vermehrung in der Dürreperiode stark beschränkt und ihre Gradation zeigt nach Ledingham in Mesopotamien zwei Maxima, das eine zur Zeit der Frühlingsregen, das andere zur Zeit der Herbstregen, während auch die Darmkrankheiten in dem gleichen Gebiete eine entsprechende sattelförmige Epidemieform haben.

Die Gefahr der trockenen Luft für die *Culicidae* ist schon erwähnt. Je nach der Luftfeuchtigkeit ist die Aktivität unserer einheimischen Culiciden ganz verschieden. Arten, die sonst nie bei Tage gesehen werden, greifen im offenen Felde nach Regen in Scharen an. *Aedes cinereus* sticht an den gleichen Stellen am Mittag nur tief unten im Kraut über dem Schuhzeug, in den späteren Nachmittagsstunden fliegt er schon über den Krautspitzen in Knie- bis Hüfthöhe an und in der Abenddämmerung fliegt er schlankweg an den Kopf. Unsere größte deutsche Culicide, *Aedes freyi*, greift häufig auch auf offenem Gelände im vollen Sonnenschein an, ebenso machen es die großen *Psorophora*-Arten der Vereinigten Staaten.

Bei diesen großen Arten ist ja schon das Verhältnis von Oberfläche zu Inhalt günstiger. Die kleineren Mückenarten stechen im freien Gelände

meist erst abends, dieselben Arten tun es im Walde oft den ganzen Tag, doch mit Unterschied je nach Wärme und Luftfeuchtigkeit der Tage. Die *Culex*-Arten gehören wohl zu den am schwächsten chitinisierten Mücken und sie sind auch am ausgesprochensten nächtlich. Der Übergang zum Nachtleben dürfte bei vielen Insekten nicht der Vermeidung lebender Feinde gedient haben, sondern wie bei den Amphibien der Vermeidung der noch gefährlicheren trockenen Luft.

Theobaldia annulata sticht im Herbst in der Hamburger Gegend abends, besonders auch in den Häusern. Im März in sumpfigen, aber kaum eisfreien Geländen schon tags mit *Theobaldia alascaensis. Anopheles maculipennis* stachen mich im Mai 1925 um 5 Uhr Sonnenzeit im Freien im vollen Sonnenschein in großer Zahl auf einer Insel mitten in der Wolga-Überschwemmung, wo damals die Luft kaum ein Sättigungsdefizit gehabt haben dürfte.

Der Unterschied der Mückenplage bei gleicher Wärme an feuchten stillen oder an trockenen windigen Tagen ist bekannt. Die Tatsache, daß so viele Mücken, und gerade die kleineren zarten oder langbeinigeren Arten ausgesprochen nächtliche Tiere sind, während die ausgesprochenen Tagtiere eher die chitinisierten Arten, wie *Aedes freyi* in Europa oder die *Jantinosoma*-Arten in Amerika sind, hat mich zu der Auffassung gebracht, daß wir diesem Trocknungsfaktor in der Verteilung der Mücken auf Häuser und Ställe, d. h. zur Erklärung der sogen. zoophilen und androphilen Mücken größte Bedeutung beimessen müssen. Aber diese Feinheiten der Verteilung weisen uns unmittelbar auf die Verhältnisse des Bodens und der Kultur als Ursache der Verschiedenheit ganz lokaler klimatischer Daten von nur einigen Quadratmetern oder Aren Weite und sie sollen hier nicht erörtert werden. Sie ergeben das merkwürdige Resultat, daß auf demselben Gehöft die *Anopheles* im Frühjahr androphil sein können, d. h. in den Häusern gefunden werden, während sie im Sommer dort fehlen, also misantrop sind, wie das Grassi beobachtet hat.

Auch im großen wird offenbar durch sehr trockene Luft nicht nur die Sterblichkeit der *Anopheles* erhöht, sondern sie werden wohl geradezu genötigt, sich an Stellen zu verkriechen, wo es feucht genug ist. Nur so erklärt es sich, daß oft schlagartig in heißen Ländern gleich nach den ersten Regen die *Anopheles* wieder da sind und damit die Ansteckungen beginnen.

Besonders beachtlich sind in diesem Zusammenhang die neuesten Ausführungen von Mayne, der in Bestätigung älterer Angaben von Bentley und Gill für Indien fand, daß infizierte *Anopheles* sich besonders in der Zeit der höchsten Luftfeuchtigkeit vom Juli bis September finden lassen. Die relativ erhöhte Langlebigkeit der Mücken unter solchen günstigen Bedingungen und der damit eintretende erhöhte Anteil relativ alter Individuen an der Population, ergeben erst die Möglichkeit dafür, daß eine größere Mückenzahl alt genug ist, um eine Infektion entwickelt zu haben. Andererseits glaubt allerdings Mayne, daß die feuchtere Luft die Verdauung und daher die Häufigkeit der Blutaufnahme begünstige und damit auch die Aussicht, infiziert zu werden. Jedenfalls sind diese an über 5000 Mücken vorgenommenen Untersuchungen eine gute Bestätigung der oben vorgebrachten Anschauungen.

Die große Bedeutung des klimatischen Faktors der Luftfeuchtigkeit liegt hier also klar zutage, wenn auch vielfach Kultureinflüsse, wie Woh-

nungsbau, sich damit verbinden, so daß eine weitere Verfolgung dieser Linie über die Grenzen unseres Themas hinausführen würde zur Betrachtung von Kultur, von Biocoenose und Boden als Seuchen bestimmender Verhältnisse.

Das gleiche gilt für den letzten klimatischen Faktor, von dessen Einfluß auf das Tierleben wir noch Nennenswertes wissen. Denn über die Bedeutung von Luftdruck, Bewölkung, Sonnenscheindauer, Strahlungsart und -intensität, atmosphärische Elektrizität, Wind, Windrichtung, sind erst einige interessante Anfänge gemacht.

So ist bekannt, daß bei windigem Wetter die Phlebotomen wenig aktiv, meist ganz verborgen bleiben. Das gleiche hat Rudolfs in sorgfältigen Untersuchungen für die Culiciden nachgewiesen. Auch die Windrichtung scheint eine Rolle zu spielen, eine ältere Mitteilung aus Panama gibt an, daß besonders diejenigen Dörfer von den Mücken eines bestimmten Brutplatzes beflogen werden und einer Malariagefahr durch sie ausgesetzt sind, von denen der regelmäßige Abendwind zu den betreffenden Brutplätzen geht, nicht die, die unterm Winde von den Brutplätzen her liegen.

So bleiben im wesentlichen die Niederschläge.

Sie sind naturgemäß für die von Hausungeziefer übertragenen Krankheiten von geringer Bedeutung. Interessant ist, daß die Regen eine als Larve parasitische Fliege, *Cordylobia anthropophaga,* welche sonst im Freien in Rattenbauten mit Vorliebe lebt, mit den Ratten in die Wohnungen treiben und zur Plage für die Menschen machen können (Afrika).

Für die in feuchter Umgebung im Freien sich entwickelnden Insekten sind natürlich die Niederschläge von größter Bedeutung, für die Glossinen, für Tabaniden, Phlebotomen, auch für Musciden, vor allen für Culiciden. So hängt in den warmen Ländern die Malariaepidemiologie größtenteils von den Niederschlagsverhältnissen ab, die ja auch mit der Luftfeuchtigkeit in untrennbarem Zusammenhang stehen. Selbst die amerikanische Dasselkrankheit (Dermatobiasis) des Menschen nimmt in der feuchten Jahreszeit zu, weil dann die Fliegen und Mücken, die die *Dermatobia* als Überträger ihrer Eier benutzt, häufiger sind, während die Sandflöhe gleichzeitig abnehmen.

Über die Bestimmung von Seuchenjahren und seuchenarmer Jahre durch das Klima nur noch weniges. Gerade die Malariaepidemiologie zeigt die Beherrschung der jährlichen Malariamenge durch die klimatischen Faktoren aufs deutlichste. Wenn auch zunächst alles widerspruchsvoll erscheint, lösen sich diese Schwierigkeiten doch leicht bei Berücksichtigung aller einschlägigen Verhältnisse. Zunächst der Gegensatz, daß z. B. im Norden in früheren Zeiten in Deutschland die Epidemiejahre die warmen, im Süden die feuchten Jahre waren. Die kühlen Gegenden haben meist Feuchtigkeit und Anophelen genug, aber in vielen Jahren fehlt die zur Entwicklung der Plasmodien nötige Wärme. Ist diese einmal reichlich vorhanden, so führt der stets erhebliche Mückenbestand zu einer heftigen Epidemie. Im warmen Lande ist die mittlere Sommerwärme so hoch, daß ein wenig mehr oder weniger in dem einen oder anderen Jahre die Entwicklungsmöglichkeit der Plasmodien nicht mehr erheblich verändert, aber in vielen Jahren mit nur wenig Niederschlägen sind die Anophelen-Brutplätze außerordentlich beschränkt und die Malaria bleibt sehr gering. In

regenreichen Jahren aber ergeben viele Gebiete, besonders die Niederungen, ausgedehnte Brutplätze, daher viele Anophelen und starke Epidemien. Aber nicht alle warmen Gegenden. Andere verhalten sich umgekehrt, sie haben ihre Malariaepidemien in den trockenen Jahren. Das sind Gebiete der Strombrüter unter den Anophelen. Diese werden durch Regengüsse ausgewaschen und daher in feuchten Jahren niedergehalten, während sie gerade in trockenen Jahren mit allmählich abfallendem Wasserspiegel in den Flüssen prächtig gedeihen und ein Heer von Malariaverbreitern stellen. Doch soll auf diese Zusammenhänge der Epidemie mit den Bodenverhältnissen nicht näher eingegangen werden.

Ähnliche Bedeutung hat die Feuchtigkeit der Jahre für die Pestepidemiologie (Bodenheimer u. a.).

Nun zum Schluß. Seit den ältesten Zeiten haben weitblickende Menschen eine belebte Ursache den ansteckenden Krankheiten unterstellt. Immerhin hat das Altertum in erster Linie die Abhängigkeit der Seuchen von Boden und Klima beachtet, und ihr zeitlich so wechselndes Auftreten hat sie damals anderen Naturereignissen, wie Erdbeben, Hagelschlägen, Heuschrecken an die Seite gestellt und mit atmosphärischen und kosmischen Einflüssen in Zusammenhang gebracht. Erst die bakteriologische Aera hatte den glänzenden Erfolg, das "omne vivum e vivo" auch auf die Ursachen der ansteckenden Krankheiten zu erweitern und nachzuweisen, daß jede Erkrankung an einer Seuche dadurch entstanden ist, daß aus einem Kranken Krankheitskeime in einen Gesunden gelangt sind. Leider wollte sie uns eine Zeitlang glauben machen, dadurch seien auch die Epidemien erklärt. Dabei ging man, wie Pettenkofer immer betont hat, am eigentlichen epidemiologischen Problem vorbei. Gilt es doch zu erklären, warum das Vorhandensein einiger weniger, sagen wir Typhusfälle in dem einen Jahre in einem Ort höchstens sporadische Ansteckungen nach sich zieht, in einem anderen Jahre aber oder in einer anderen Stadt eine schwere Epidemie macht.

Auf die Probleme, die hier vorliegen und die Möglichkeit, ihre Gesetze zu erkennen, hat die medizinische Entomologie auf ihrem Gebiete ein so helles Licht geworfen, daß schon eine deutliche Umkehr von rein bakteriologischem Denken sich vollzieht. Die Tatsache, daß eine gewisse Vorhersage des Verlaufes der jährlichen Malariaepidemie (Gill), oder einer Pestepidemie (Bodenheimer) möglich ist, kann doch nicht ohne Wirkung bleiben und muß alle Hygieniker zur Erkenntnis bringen, daß Klima, Boden und Kultur in ihrer Beziehung zur Bionomie des Krankheitserregers und Wirtes das epidemiologisch entscheidende sind. Mit dem alten Denken, daß nur die Infektionsmöglichkeit die Epidemie macht, ist der Rückgang der Malariaendemie in Europa, nördlich der Alpen, nicht zu erklären. Die Zusammenhänge von Kultur- und malariogenen Umweltfaktoren reichen aber so gut wie völlig dazu aus, die Änderungen der Infektionswahrscheinlichkeit und aus ihr der Rückgang der Endemie zu verstehen.

Vielleicht darf ich hier zum Schluß mit einem phantastischen Gedanken spielen. Die Moorforschung hat uns gelehrt, daß die Haseln im Rückgang vom Norden nach Süden sind, d. h. daß seit langer Zeit das Sommerklima in den nördlichen Teilen Europas sich abkühlt. Das zeigen auch für die letzten Jahrzehnte die mittleren Monatswärmen aus Schweden.

Durchschnittstemperatur.

1756—1800	17,68°	16,35°
1801—1850	17,08°	16,26°
1851—1900	17,00°	15,55°
1861—1910	16,60°	15,17°
	Juli	August

In gleiche Richtung weist das Vordringen manches Gletschers.

Könnten nicht das Rückweichen der Haseln, Rückweichen der Malaria, Rückweichen der Pest nach Süden in diesem Sinne teilweise analoge Vorgänge sein, die nicht im bakteriologischen Laboratorium, sondern in den Untersuchungen der Meteorologen und Geophysiker über die Wärme- und Kälteperioden, auf der einen Seite, in den Studien der Biologen im Gelände, im Acker- und Städtebau auf der anderen Seite ihre Lösung finden?

Die allgemein-naturwissenschaftliche Bedeutung dieser epidemiologischen Forschung ist die, daß wir hier tief in die Gradationslehre der Organismen eindringen. Ist doch Epidemiologie im Grunde nichts weiter als Gradationslehre der Parasiten und mithin ein Abschnitt aus ihrer Oekologie.

Beeinflussung der Farbe von Mücken und ihren Larven.

Prof. Dr. E. Martini und Dr. J. Achundow, Hamburg.

Bei Versuchen über die Reaktion von *Anopheles*-Larven auf Licht in unserem Laboratorium bemerkten wir, daß die auf hellem Grunde gehaltenen Larven rascher wuchsen und heller wurden. Da wir für die Versuche uns bereits verschiedenfarbige Zuchtgefäße (weiß, grau schwarz, braun, grün) beschafft hatten, wurden diese gleich zur Verfolgung der neuen Beobachtung verwandt. Weiß, grau, grün gaben helle, braun und schwarz tiefdunkle Larven. Letztere blieben auch kleiner. Auch die Puppen zeigten denselben Gegensatz sehr deutlich. Das gleiche ließ sich erreichen mit den Larven von *A. maculipennis, A. bifurcatus, Th. annulata, Aedes dorsalis* und *A. salinus,* nicht mit *Stegomyia fasciata.* Die Larven im hellen Gefäß wurden bei letzterer grösser, aber sahen nicht dunkler aus als die in den anderen. Abgesehen vom dunkel durchscheinenden Darm waren sie farblos. Die dunkle Färbung bei allen andern untersuchten Larvenarten gehörte vor allem der Rückseite an. Die Unterschiede wurden umso intensiver, je heller das Licht war, dem die Larven ausgesetzt wurden. Eine Verdunkelung von oben und Spiegelbeleuchtung mit hellem Himmel von unten gab weiße Larven, nicht umgekehrte oben hell und unten dunkel gefärbte, d. h. die Oberseite reagierte auf den hellen Grund, die Unterseite reagierte nicht, verhielt sich also wie die Stegomyien. Es fehlt ihr offenbar die Potentialität für Pigmentbildung, in beiden Fällen wohl aus dem gleichen Grunde, nämlich daß unter natürlichen Verhältnissen solche Anpassungsfähigkeiten nicht gebraucht werden und daher auch nicht vorhanden sind. Die Unterseite der *Anopheles*-Larven zeichnet sich stets gegen den mehr oder weniger hellen Himmel; die Stegomyien sind ursprünglich Höhlentiere und wie so viele solcher pigmentarm. *Anopheles*-Larven ganz im dunkeln gehalten, blieben hell.

Ein Einfluß der Lichtmenge allein, oder der Gesamtmenge des kurz- oder langwelligen Lichtes ist aus diesen Versuchen nicht zu entnehmen. Denn sonst könnte die intensivere Beleuchtung nicht die Larven auf dunklem Grund noch dunkler, die auf hellem aber gleichzeitig noch heller machen, denn für beide war ja sowohl die gesamte Lichtmenge als die Menge kurzwelliger Strahlen gesteigert.

Auch der Umdrehungsversuch spricht in dieser Richtung.

Bei den *Anopheles*-Imagines gaben die auf weiß gezüchteten Larven helle Männchen und Weibchen, die auf schwarz gezüchteten dunkle. Der Unterschied war ziemlich auffallend und entsprach durchaus den in der Natur beobachteten Unterschieden, die wir z. B. in Kleinasien bei *An. maculipennis, A. elutus, A. bifurcatus* und *A. algeriensis* feststellen konnten. Bei den anderen Mücken gab es keine deutlichen Unterschiede. Die Unterschiede waren auch dann deutlich, wenn nur die Larven auf verschiedenfarbigem Grund gehalten, die Puppen aber gleichen Lichtverhältnissen ausgesetzt waren.

On the Necessity of a Revision of the Rules of Entomological Nomenclature concerning groups of Lower Rank than the Specific one.

Roger Verity, M. D., Florence, Italy.

Article 14 of the "Rules of Entomological Nomenclature" proposed by the British National Committee on Entomological Nomenclature (Proceedings of the Entomological Society of London, 1925): — "A name of lower rank than that of a subspecies has no status in nomenclature, the accepted meaning of subspecies being a geographical or (in the case of parasites) host variation."

It has been felt by many workers, desirous to follow these Rules, that this article is unsatisfactory and entirely inadequate when one tries to conform to it in working out variation. Our present state of knowledge has surpassed it and one needs something more accurate and definite.

To begin with the term of "subspecies", it might be taken to mean an incomplete stage of a new species or what one supposes to be a future species in formation. It has thus been a very unhappy choice as the term for designating geographical variations, which should simply imply that surroundings have changed in a certain way the aspect of a group of individuals living in them and should not involve any other supposition. In practice the term "subspecies" has been used by Naturalists in every possible sense, from that of doubtful species to mere individual variations occurring frequently in some locality. To maintain it now with a new definite meaning would increase the confusion already existing in literature. Is it not advisable to sink it henceforth as a synonym of "race", a term which has the advantage of not suggesting any undesired significance? The latter, however, also requires to be restricted and used in a definite way. Entomologists have used it indiscriminately for groups whose characteristic features are due to the influence of different sorts of surroundings on individual development as well as for those whose features are due to different hereditary factors and which breed true as to these particular features in whatever surroundings they are living. In connection with Mankind it is currently used in the latter sense when one talks of the Caucasian race, the Mongolian race, etc. They are not species, because, although as a rule they live apart from each other, when they do meet, they can interbreed and produce an indefinite number of perfectly fertile generations; they are not, on the other hand, real geographical variations either, because they breed true in all sorts of environments.

Naturalists have discussed the differences between organisms of this sort during a century and a half, some maintaining that they were distinct

species and others that they were not, but they have never come to an agreement. Is not the cause of this that both parties were right in denying the correctness of the other's conclusion, because they had to choose between two solutions neither of which fitted facts: "specific distinction" or "geographical variation"? It is on this account I have, in some of my Monographs on various groups of Lepidoptera, proposed to define this phenomenon and to call it e x e r g i s m. In practice I have found that this concept covers the facts perfectly and does away with the difficulties of the past, because a n e x e r g e is an absolutely natural group of races which have a more or less demonstrable origin in common.

Following these remarks I suggest that three kinds and ranks of relationship should be recognized below the generic one: —

1. R a c e s, produced by the direct action of different surroundings on the development of the individuals, so that their features must fall within the limits of the elasticity allowed by the hereditary factors they have in common. They can exist intermixed in the same lands, according to the various sorts of surroundings the latter afford in different spots, and they are connected with one another by individual and local transitions. They are thus the true geographical variations, because the differences in their features are entirely produced by local causes.

2. E x e r g e s, in which the hereditary factors of some features are different, but interbreeding produces perfectly fertile offsprings. They always inhabit different land-areas, except in particular cases, such as large mountain chains and plains, which afford very different surroundings and climates within the same area; they often consist in a long chain of races stretching even from one continent to another, such as from Thibet to Morocco or from N. E. Siberia to Central Europe. They do not often intercross where they meet, on the boundary between their areas and, as a rule, they fight each other and exclude each other. The so-called "races" of Mankind are typical exerges and the domestic breeds, artifically kept apart, fall in the same category.

3. S p e c i e s, in which both the hereditary factors of some features and those which control reproduction are different. They can intermix, but they never interbreed or, when they do exceptionally, they only produce hybrids, which are never fertile for more than a few generations.

The Principle of Continuity in Nomenclature.

F. Heikertinger, Wien.

In my opinion the chief problem in Nomenclature is contained in the question: which of several names given to a genus or a species is the valid one? The Rules of Nomenclature attempt to solve the problem by means of the principle (law) of priority. Has this principle been successful? Do we find today uniformity and stability in Nomenclature? The answer can only be in the negative; and it is often just this principle of priority which is the cause of the destruction of old names. The question, therefore, arises as to whether this destruction is inevitable. Is there no other principle which has all the great advantages of the law of priority without its disadvantages? In order to find such a principle, we must first be clear as to the aim of Nomenclature. This aim is to have one and the same name for each animal throughout the world in the past, in the present, and in the future. Does the principle of priority attain this aim?

1. Is only one name in use for each animal in the whole world? No, certainly not. The great green Grasshopper, for instance, bears in the scientific literature of today three generic names: *Locusta* Deg., *Phasgonura* Westw., and *Tettigonia* L. Moreover, *Locusta* is also used for the Migratory Locust *(Pachytylus)*, and *Tettigonia* for a Cicada. In an exellent modern scientific periodical (1927) the title of a paper. "Über die geographische Verbreitung der Ipiden —" is translated as "On the geographical distribution of the *Scolytidae* —". The American entomologists call *Bremus* what the European entomologists call *Bombus*. And so on.

2. Does the principle of priority protect the old application of a name? — Everyone should ask himself, how many of the good old scientific names of common species which he has learnt as a student are still alive. Who is sure of knowing the correct modern names of the commonest animals? I looked in vain for the name *Epeira* in the latest book on the spiders of Middle Europe (1927). — *Chrysomela* L. is now *Chrysolina* Motsch., and *Melasoma* Steph. is now *Chrysomela* L. Who in these circumstances can know what is meant with *Chrysomela* when he comes across this name in literature? Every systematist has met with scores of such cases in his own experiences.

3. Does the principle of priority stabilize a name for the future? — No. Any name may be sunk today or tomorrow. The principle of priority has no provision for making a name inviolable; but it is a good principle for destruction.

To sum up: priority does not accomplish the three chief claims of Nomenclature.

But there is another principle which will satisfy these claims. I published it many years ago in this simple form: The valid name of a genus or a species can only be that name which the monographer finds in common use in science, be this name the first given or not. If two or more names are in use for a genus or a species, the monographer must choose that name the selection of which causes the least disturbance in scientific literature.

If there is no name which can be considered as "commonly used", or if there are other difficulties, the earlist name must be fixed, because this name is likely to be the most widely used. The right to fix a name is reserved for the monographer. To indicate such fixation, the word (fix.) (= fixum) should be appended to the name and be published in a monograph, catalog, etc.*), and be quoted in the Zoological Record and similar works. A name fixed in such a manner can never be changed or rejected on purely nomenclatorial grounds.

How would this rule work? There are three possibilities:

1. Of two or more concurrent names one is generally or at least chiefly used. Example: *Chrysomela* L. generally used, *Chrysolina* Motsch. never used. Such cases are very frequent. There is no doubt possible; the decision is easy and clear.

2. Two or more names are in use, here and there, but no one predominates. The decision would be difficult. This case is rare. There are two possibilities:

a) After an impartial scientific investigation the monographer takes one of these names as the one probably most in use and fixes it. The fixation must remain valid in all cases and for ever, even if other systematists disagree with the monographer.

b) If the monographer cannot arrive at an opinion as to which name is most in use, he fixes the oldest name.

3. There are names which cannot be considered as being "in use", because they have existed less than 20 or 30 years, or because they belong to groups of no general importance and are therefore known only to specialists. In such cases the oldest name must be fixed.

I ask the taxonomists to give this principle an impartial trial in their special groups. They will find that it works precisely as the principle of priority and quite in the same sense, except in those few cases in which priority operates against the aim of Nomenclature by destroying the stability and continuity of good old names.

But the chief value of the principle of continuity is not that it establishes a new rule in Nomenclature, but that it approaches the subject with a new condition of the mind. There would be no further dispute about the "right" of a name or the "justice" of priority; there would be no "right" or "justice" or "priority" to defend. *Fiat justicia, et pereat mundus* would no longer apply. One name is as good as another, provided

*) If there is only one name, no fixation is needed.

that the name gives continuity from the past to the present time and that it is fixed for all future times.

This is the true aim of Nomenclature, the one and only very great nomenclatural problem. The principle of continuity solves the problem in a direct and simple manner without the admission of exceptions and nomina conservanda and without the necessity of opinions being rendered by a commission. The principle will bring peace and harmony to our sick and devastated Nomenclature.

I well know that there still remain many questions to answer and doubts to allay. Those systematists who are interested in the matter are invited to consult my former publications, where they will find the answers to many of the questions that may be in their minds. The principle of continuity being too astonishing, and still too strange and too new, we cannot expect this Congress to accept it. I shall therefore abstain from bringing forward a resolution on the subject. If taxonomists will give the principle a trial, I feel confident that some day the time will come to vote upon it.

DISCUSSION.

Dr. C. W. Stiles cited the favorable influence of the Law of Priority on the names of birds. He emphasized the point that each country and each speciality should have its own court for decision and that the work of the International Commission should be confined as far as possible to cases of appeal.

Dr. P. P. Babiy: — I would like to emphasize the fact that the „Kontinuitätsprinzip" is really not in contradiction to the Principle of Priority, but is in reality that principle plus a good deal of common sense.

Index to the Literature of the Species of Insects.

E. T. Cresson, Jr., Academy of Natural Sciences, Philadelphia, Pa.*)

It is impossible to do constructive taxonomic work without a species catalog, a catalog which is an index to the literature as regards the species involved. It is evident that the enormously increasing quantity of new names proposed, taxonomic descriptions, synonyms, etc., must in some way be made available to the taxonomist, or insect taxonomy is doomed to strangle from insufficiency of its own mechanism. The present methods of preparing and publishing catalogs do not adequately accomplish this, because they become obsolete as soon as there is a change in the systematic arrangement of the species, and now that the number of species is becoming so enormous, the republication of such catalogs has gotten to be an item of considerable expense. The numerous and in some cases voluminous catalogs which have been published, and now occupy our bookshelves unconsulted, are examples of this extravagance.

The well known "Catalogus Coleopterorum" and "Catalogus Lepidopterorum" which are now being published are the best examples we have of a satisfactory catalog on account of the complete index to the genera, species and synonyms they contain. They are, however, systematical in their arrangement, and in all probability will in time give way to others. These catalogs cover only the Coleoptera and Lepidoptera, while the Diptera, Hymenoptera and the other orders have nothing up to date on the world species.

The Alphabetical Index to North American Orthoptera, by S. H. Scudder, published in 1901, is the nearest approach, to my knowledge, to a purely alphabetical index. Unfortunately the species are arranged in alphabetical sequence under genera, which latter are likewise in alphabetical sequence. In using this index one must know under what genus to look for the desired species. Another index, however, is appended which furnishes this information. I do not consider this a satisfactory method, involving two indices, one of which could be slightly rearanged making the other unnecessary.

In the study of the two families of Diptera in which I am specializing, viz. the Ephydridae and Micropezidae, it was necessary for me to have a complete and efficient index to the described species of the world. The index which I have worked out for this purpose has proved to be so practical that I unhesitatingly recommend its style to all taxonomists.

This index is in card form, with the generic and specific names arranged in alphabetical sequence without regard to their supposed relationship. The

*) It being impossible for the author to attend the Congress, Dr. P. P. Calvert, kindly presented this paper — E. T. C., Jr.

first line of a species card is composed of the species name, its original generic name, its author, and the date of publication. The next line or two contains the bibliographical data, sexes described and type locality. The following lines cite subsequent references including generic changes, synonymy, etc., as recorded in the literature, in chronological sequence. I thus have a complete record and index to date of every species. The generic cards are similar. It seems to me that such an index could be published in book form, with supplements to take care of the current literature.

Dr. J. C. Bradley, with whom I have often discussed the subject of cataloging, thinks that my ideas should be brought forward at this time; so I present for your discussion a method which I think is a possible solution of the problem before us. I use the term "Index" as being more appropriate than "Catalog".

The following specifications, I think, are essential to such an Index.

1. The specific names shall be arranged in alphabetical sequence, irrespective of their supposed relationship.

2. The bibliographical references to the same shall be arranged chronologically under their respective specific names.

3. All references, including those in faunistic lists and economic publications, should be cited.

4. The index to cover the literature to a certain date, after which supplements be issued periodically to keep up to date.

5. The index and supplements shall be printed from linotype or by similar method, the type to be retained and stored in some safe depository for use in printing new editions without change of setting (I may note here that this requirement will eliminate resetting of type matter, thus eliminating much expense, as well as the chance of errors creeping in. Such errors as have been made can be corrected in the supplements).

6. No corrections should be made by the cataloger except such as are evidently typographical; and nothing which gives the cataloger's personal opinion.

The above cover the essentials, but there are many important details which would have to be worked out by the editing committee.

The Index may be issued in parts, each covering an order. In the case of the large orders as Coleoptera, Lepidoptera, Hymenoptera, and Diptera it may be convenient and advisible to divide.

To make such an Index ideal, an appendix should be compiled which gives the genera alphabetically or systematically arranged, with all their recorded species listed under each in chronological sequence. Such an appendix will give the student control of the literature to all the species which have been referred to each genus. This appendix would necessarily have to be issued with each supplement.

This, I trust, presents the essentials of my idea, but the sample given below will probably best show the manner in which the references can

be cited in the Index. These examples would cover most situations, but there would no doubt be situations requiring consultation with some taxonomist specializing in the group involved.

Index to the species Discomyza maculipennis (Wiedemann) 1758—1899.

balioptera (Discomyza) Loew, 1862.
  Mon. Dip. N. A., 1, p. 140. ♂ . . . . , . Cuba
maculipennis (Notiphila) Wiedemann, 1824.
  Anal. Ent., p. 57 . . . . Ind, orient.
  1830. Wiedemann, Aus. Zweifl., II, p. 574, (Homalura).
obscurata (Discomyza) Walker, 1860.
  Proc. Linn. Soc. Lond., Zool., IV, p. 169. ♂ . . . . . . Celebes
pelagica (Discomyza) Frauenfeld, 1867.
  Verh. z.-b. Ges. Wien, XVII, p. 451, pl. 12, f. 13. ♂♀ . . . . Nicobar Isl.

Here we have the general style of presentation; the species arranged alphabetically, with their bibliographical references arranged chronologically. As you see the first line "species line" of each species is composed of the original specific and generic names, author and date. The second line "(original reference)" contains the original bibliographical reference, sexes described if known, and type locality. All the subsequent references to this species follow as shown, giving synonymy, generic changes and other information which may be considered essential, and, at the extreme right, additional geographical distribution. Whether or not the citations of synonyms, etc., should occupy a separate line is a matter of detail; but brevity should be maintained without creating ambiguity.

Supplement, 1900—1925.

amabilis (Discomyza) Kertesz, 1901.
  Term. Fuzet., XXIV, p. 421. — — — — — — — — Singapore
  1928. Meijere, Tijd. v. Ent., LI, p. 166.
  = Notiphila maculipennis Wied.
balioptera (Discomyza) Loew, 1862.
  1925. Cresson, Trans. Am. Ent. Soc., LI, p. 242.
  = Notiphila maculipennis Wied.
maculipennis (Notiphila) Wiedemann, 1824.
  1908. Meijere, Tijd. v. Ent., LI, p. 166 (Discomyza). — — — — — Java
  (*Discomyza amabilis* Kert.)
  1914. Bezzi, Phil. Jour. Sc., VIII, p. 322 (Discomyza). — — — — Phil. Isl.
  (? *Discomyza obscurata* Walker).
  1925. Cresson, Trans. Am. Ent. Soc., LI, p. 242. — — — — Formosa, Guam
  (*Discomyza balioptera* Lw., *D. pelagica* Frauenf.), — — Fr. Indo-China
pelagica (Discomyza) Frauenfeld, 1867.
  1925. Cresson, Trans. Am. Ent. Soc., LI, p. 242.
  = Notiphilia maculipennis Wied.

Here you will see the manner in which the Supplement continues the indexing. Note that the "species line" remains the same as in the Index proper. This enables one to locate the proper species in the Index for previous references. Synonyms may be cited within parentheses and relegations to synonymy indicated by an equal sign, but different type faces may be used to advantage here.

Part of the Appendix showing the
Species of the genus Discomyza Meigen, 1830.

DISCOMYZA Meigen, 1830.

incurva (Psilopa) Fallen, 1823.
marginella (Psilopa) Fallen, 1823 — — — — — — — — — — — Ephygrobia
maculipennis (Notiphila) Wiedemann, 1824.
obscurata Walker, 1860 — — — — — — — — — — — — — maculipennis Wied., 1824.
cimiciformis Haliday, 1855. — — — — — — — — — — — — Clanoneurum
balioptera Loew, 1862. — — — — — — — — — — — — maculipennis Wied., 1824
tenebrosa Walker, 1865.
pelagica Frauenfeld, 1867. — — — — — — — — — — — — maculipennis Wied., 1824.
punctipennis v. d. Wulp, 1896.
amabilis Kertesz, 1901. — — — — — — — — — — — — maculipennis Wied., 1824.
vorticis Becker, 1903.
similis Lamb, 1912.
u-signata Cresson, 1926.

Here we have the style which may be used for the "Appendix" or "Generic List". This example presents all the species which have been described and otherwise referred to the genus *Discomyza,* arranged chronologically. It is almost self-explanatory, but note may be made to the removal of *marginella* to the genus *Ephygrobia,* and of *cimiciformis* to the genus *Clanoneurum;* while *balioptera, pelagica* and *amabilis* have been considered synonyms of *maculipennis.*

The first or "Index edition" of the Appendix would naturally be of considerable size, but the "Supplement editions" need not contain those species which have previously been removed and otherwise treated, thus greatly reducing the size of these Appendices. This becomes evident in the case of the genus *Musca* to which well over 500 species have been referred, but now contains only a dozen or so.

The present method of publishing Catalogs with the genera and species arranged systematically always necessitates republication as soon as the systematic sequence of the species is revised, or the Catalog is out of date. This reprinting, particularly for such a Catalog of all Insecta, would be very costly and certainly an economic impossibility.

An Index with the species and genera arranged in alphabetical sequence, with their bibliographical references cited in chronological sequence under each name, but without regard to their relationship, would obviate the necessity of republishing. By the issuance of supplements to take care of the records in the current literature, this Index would be kept up to date. We could then have an economically possible Index to the literature of all the insect species of the world.

I think this Congress should seriously consider the preparation of such an Index.

Discussion:

J. Silvestri: — We need careful catalogues to facilitate the knowledge of the species described and we must recommend the publication of such catalogues as much as possible, but as the lack of funds and the lack in some cases of competent men would delay the publication of these useful books of reference, it is necessary to urge that the "Zoological Record" should be continued with the greatest care and be assisted by everybody in

the best manner possible, and that at least the parts referring to each order should continue to be sold separately as at present, so as to render the purchase possible to the numerous specialists.

Fred. Muir: — Catalogues and periodical "Records" are absolutely necessary for the advancement of Entomology, both economic and scientific. Eventually we shall have to have international cooperation for all this work, and the sooner we can bring this about, the better it will be for Entomology. No greater benefit to Entomology could be made than donations towards a fund for the purpose of carrying on this work. A Card Catalogue system I personally consider not so convenient as a book form for Catalogues and Records*).

*) Cf. vol. I, Report of the Permanent Seeretary.

On some Problems of Distribution, Variability and Variation in North American Siphonaptera.

Dr. Karl Jordan, Zoological Museum, Tring, England.

(With 11 text-figures.)

The International Congresses of Entomology being organized for the purpose of uniting the various interests of the pure and applied branches of this science, an address on some problems relating to an order of blood-sucking Ectoparasites does not seem out of place at this gathering where Applied Entomology is represented by so many illustrious exponents. In selecting the North American fleas as the subject of my address, I have chosen a group of insects which is close to my heart — in a figurative sense — and the study of which is not only most fascinating, but has also been rendered very pleasant to me in consequence of the great help I have received and am receiving by my colleagues in this country. When I came over to the U. A. S. last year, largely for the purpose of comparing the types of fleas contained in the U. S. National Museum at Washington, D. C., and in some other institutes of Eastern cities, my task was made easy by the readiness with which everybody came to my assistance in the true spirit of solidarity of all scientists, and I am very glad to have here an opportunity of making such a statement in public. I have thus seen all the North American species known to science, with the exception of one, which the author, who was abroad last year, unfortunately had placed into his own collection and thereby rendered unavailable. There is still much material stowed away in collections which I have not visited, and, as we shall see, large tracts of the country remain as yet unexplored as to this order of insects. We must therefore expect that the number of genera and species of North American fleas will be considerably increased in the near future.

The first American Entomologist who studied fleas extensively, and who laid the foundation of our knowledge of the Nearctic Siphonaptera, was Carl Fuller Baker, who began tentatively in 1895 and nine years later, in 1904, issued a Revision in which a large number of new species were described and mostly also figured. In this Revision, a work of great merit, Baker enumerates 51 species from America north of Mexico. As 3 of these species are not distinct, while on the other hand one suppressed by Baker *(Ctenocephalus felis)* is distinct, the total number of species mentioned in the Revision as being found in North America is 49. Since 1904 the number has gradually grown to 131. This increase within 24 years is to a large extent due to the efforts of the late N. Charles Rothschild to secure material from the United States and Canada. He was particularly successful in stimulating field entomologists and taxidermists in British Columbia, Alberta and Arizona, and as he also received generous

contributions from Dr. Carroll Fox and others, a considerable material of North American fleas has accumulated in the N. C. Rothschild collection.

131 species in a country as large and physiographically as varied as America north of Mexico does not seem a large number, if we consider that no less than 46 species are known from that small island called Great Britain, which is about the size of New England plus the State of New York. These figures seem to indicate that North America has been badly treated in creation; but they are misleading. For, while in Great Britain nearly all the species occurring are known, the number of undiscovered species of fleas in North America is undoubtedly large. I estimate the total number actually occurring in the United States and Canada to be well over 200. Though our knowledge of the Siphonapterous fauna of these countries, therefore, is very incomplete, I feel nevertheless confident that the evidence as to distribution and relationship with which the 131 species known from North America furnish us will not be contradicted, but only extended, by the discovery of some four score of new species and a variety of new genera. If we estimate the number of species in collections from all countries at 800, and if we divide the Globe into 6 faunistic areas, North America is already close to the average. It shares with Great Britain, Switzerland, Russia, South Africa and Argentina the honour of having the fauna of Siphonaptera better explored than the rest of the world, many countries in the tropics presenting nearly a blank on a flea chart. Taking all countries together, I do not think that we know more than one-third of the species of fleas actually in existence, the total being presumably between 2500 and 3000.

As the fleas depend for their livelihood on mammals and birds as hosts, one might be inclined to assume that the number of species of fleas was proportionate to the number of species of hosts. But that is only true to some extent. For not every type of mammal or bird has a flea of its own, and, moreover, fleas are lumpers in systematics and group their hosts according to their own needs rather than according to the catalogues of mammalogists and ornithologists.

If we divide America north of Mexico into an Eastern, a Central and a Western area, we find a remarkable difference in the number of fleas known from each area. Leaving out of consideration 9 species which are introduced and therefore not truly Nearctic, 31 species are known from the Eastern States, from Quebeck to Florida westward to Ohio, 26 from the Central States, and no less than 107 from the Western side of the Continent, from California, Arizona and New Mexico northward.

The number of species at present known from any one locality depends, of course, on the intensity with which fleas have been collected and on the number of species existing in the places where collecting has been going on. In order to give you an idea of the degree of attention which has been paid to these Ectoparasites I mention that 26 indigenous species are known from Washington, D. C., and the neighbouring districts of Maryland and Virginia; from Iowa only 8; from Tenessee, Louisiana, etc., none; from Texas 3; from Colorado 11; from Arizona 21; from the coast district of California 32; from Alberta 39; and from British Columbia 41. The Central area probably has no species of flea which does not also occur

elsewhere; the species there obtained are immigrants either from the North, the West or the East. The Southern Atlantic and Mississippi States are as yet practically a blank. May I express the hope that those biologists who are in a position to obtain fleas in these States will do so? In Louisiana, for instance, some years ago over 4 million muskrats were killed for the sake of their pelts and not a single flea from this rodent is in the collections at Washington and Tring. It looks to me as if insects must first become dangerous before they arouse an interest, except with a limited number of unselfish friends of Nature. Perhaps this appeal will bear fruit; perhaps we shall have to wait for the outbreak of some flea-carried disease in the Southern Mississippi States — which heaven prevent!

Among the 31 species so far found in the Eastern States there are 17 which also occur in the West or at least are there represented by special subspecies, leaving 14 which are restricted to the East, but probably extend on to the Central plains, at least in the North. Some of these 14 are purely Northern forms, being only known from New England and the neighbouring States; others are of wider southward distribution. In the Western area, on the other hand, the number of indigenous species confined to the West, but partly descending eastward into the foothills, is 90, more than six times as many as in the Eastern States.

The contrast between East and West is still more striking, if we consider the distribution of the genera as shown in the following table:

33 Genera:
- Introduced 3
- N. America & Old World 9
- N. America & S. America 1
- Purely N. Amerikan 20
  - Restricted to East 0
  - Found East & West 6
  - Restricted to West 14

It is remarkable to note that, while 14 genera are restricted to the West, the Eastern States have no single genus of their own. This inferiority of the Atlantic States requires explanation. And that raises the question of the origin and relationship of the North American fleas.

The little we know of the fleas of Central America shows that, with a few exceptions, the Nearctic fleas are of a Northern stock. Texas and California share a genus of bat-fleas with South America, and the interesting flea (*Pulex porcinus* J. & R. 1923) discovered in Texas on the Peccari — it is the nearest ally of the Human flea — is possibly a Central American species; but all the other indigenous species are of Northern relationship. If the fauna were of Southern origin, one could easily understand why the West as being continuous with the South had received so many more species than the Eastern States which, in geological times, were separated from the South by the northward extension of the gulf of Mexico. But as there was no similar barrier in the North, why the great differenec in the flea-population between the East and the West? At first sight one might be satisfied with saying that the Western area is so much larger than the Atlantic area and therefore can support a larger population. But size as such is misleading: the coast district of California, for instance, from San Francisco to San Diego, is much smaller than the aggregate of the Atlantic States from New England to Virginia, and nevertheless more species of fleas are found

in the Californien coast hills than in all the Eastern States together. The explanation of the difference, therefore, must be sought elsewhere.

The fauna as existing today in any given district is an expression of 1) the geological history, 2) the accessibility, and 3) the factors of life, of that district.

In the glacial period life was practically destroyed in the Northern Atlantic States, whereas in the Pacific half of the continent glaciation was less complete, so that life could persist in many cases. This, no doubt, accounts to a larga extent for the greater abundance of species in the West. And possibly, some of the species existing in the Northern and Central Atlantic States before the glacial epoch may have survived in the South-east, but have not yet been discovered, our records of fleas from the Southern Atlantic States being excessively meagre. When these States are better explored as to their flea-population, we shall find that there are pre-glacial species with a northward distribution and post-glacial arrivals with a southward distribution. However, the geological history does not entirely explain the comparative poorness of the Eatern States. There is evidently some quality in the one area which is missing in the other. The distribution of the Common Human Flea in the United States affords evidence of some such kind. The species is common in the South and West, but practically absent from the Central and Northern Atlantic States. Here is a species which would find plenty of hosts — and, as we know, very hospitable ones, whose blood is presumably just as sweet as that of a Westerner — a species without a competitor who might crowd it out, and without a barrier to keep it away. Then why does it not also here make good its name: the Common Human Flea? Well, we know that this *Pulex irritans* does not thrive in a hot moist climate, but that it abounds even in the Tropics at higher and drier altitudes wherever Europeans have settled. I should not be surprised to learn that the species feels quite at home high up in the mountains of North Carolina, although it is unable to stand the prevalent summer-climate of the low levels, the climate of Ellis Island, no doubt, acting as a de-fleaer of the immigrants. Anyhow, the biological factors which decide the practical absence of the species from the Atlantic States can be tested by experiment, which would be a useful piece of work for some young entomologist to take up. This example shows that it is neither inaccessibility, nor the absence of a suitable host which prevents this particular companion of mankind from settling in the Alleghany States, and that there is something amiss in the conditions of life which the country offers. And what applies to one species, may very well apply also to others. The Common European Fowl-flea is a case in point; but there the deficiency is with the West. The species is frequent in the Eastern States on domestic fowl and in the nests of wild birds, but does not occur in the Rocky Mountains and farther west, where the domestic fowl is infested with another bird-flea, which is not known to occur in the Eastern States (and is not found in Europe). As the Eastern hen-flea breeds in birds' nests together with other fleas, there is no ground to assume that the presence of another fowl-flea restricts its distribution to the Eastern States, and vice versa; and we must conclude that the distribution is determined by some other biological factor or factors, the nature of which can be ascertained by experiment.

If the conditions of life in a district which is accessible and which offers the particular food necessary to that insect have such a deterrent effect as here exemplified, we must expect that the species which exist under these same conditions are affected, modified, in some way and to some extent. This consideration leads us to an enquiry into the variability of the fleas and to the problems of variation they present.

The difference in the number of genera and species in two districts equally accessible to the original stock may be due to the dying-out of some species in one district. It was Cope who first explained that the disappearance of species from natural causes was due to restricted variability. It is indeed easily conceivable that a species or race well adapted to a certain definite condition of life has much less chance to survive under changed conditions than a morphologically and physiologically variable species which offers a broader basis for new adaptations. The old nobility gradually dies out and a new one arises from the promiscuous non-specialized lower strata of life.

Research in Biology is based on individuals: their bodies, functions and products; and the knowledge of the differences of individuals is the foundation of sound systematics. The sum of the individuals of a species living in the same district are a synpatric community. Variability is the state of being different as individuals of a community. Variation is the state of being different as a community of a species. Where the individual variability has not been studied, systematics are left hanging in the air, and work of this type is a mere nuisance. It was the great merit of the late Charles Oberthür that he as the first among collectors advocated the amassing of long series of specimens which would enable the student to ascertain the range of variability of a species in the particular district. It is an advice of perfection, which, however, can be followed without difficulty in the case of fleas, as these insects do not take up much room even as permanent slides. It has been most interesting to me to study variability and variation in some very different groups of insects in which I am interested, and to compare the results. If we contrast, for instance, the sun-loving butterflies or day-flying moths with the fleas, which live on mammal and bird and in their nests, the Lepidoptera sipping honey and the fleas sucking warm blood, the former conspicuous, the latter microscopic, one is a priori inclined to think that insects so widely different in aspect and habit can have little in common as to their variability and variation. The broad facts are nevertheless the same in all orders.

The fleas being more or less uniform in colour, the individual differences are essentially observed in the details of structure. The specimen here figured (text-fig. 1) respresents a species *(Ctenophthalmus pseudagyrtes* Baker 1904) characteristic of the Eastern side of North America, being very common on moles and mice and not occurring in the Rocky Mountains. It is the only representative in America of an Old World genus of which an abundance of species are found in Africa, Europe and Palaearctic Asia. The body is covered with a multitude of bristles, which have a definite arrangement. Those of the body lie flat, rendering the insect slippery, so as to enable it to rush through the fur of the host without hindrance; the bristles of the tibiae and tarsi, however, divaricate, preventing the flea from falling out of the fur, and taking hold of the host's hair for

support when the flea drives its sucking tube into the skin. Closely allied species are often distinguishable by differences in the bristles, the discovery of such differences being frequently a very laborious task, for this reason: the number of bristles varies in the same community of specimens and often also their length. Now, whereas in Lepidoptera the individual differences (apart from size) can only be stated by a description in words, the differences in the number of bristles of a flea can be expresed by arithmetical figures and therefore the possible total of different individuals by arithmetical formulas. It may be of interest to those who would like to distinguish by a name every specimen of insect which is different — as well as to those who base their conception of a human community on the assumption of equality of individuals — to know that there are no individuals which are mathematically alike. Nature is not a mathematician, but a manufacturer with

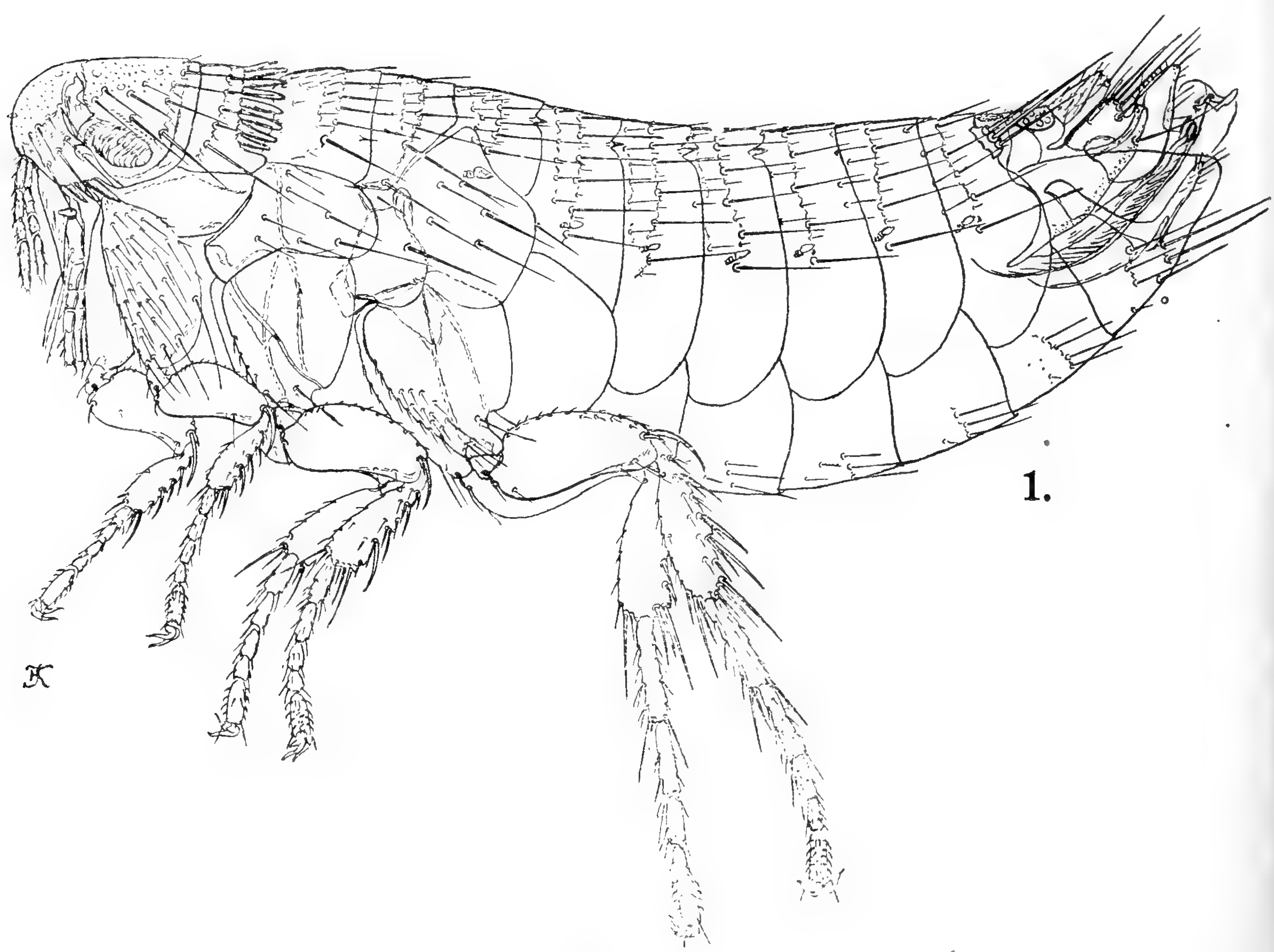


Fig. 1.

a large profit and loss account whose bills are all marked e. & o. e. Take as an illustration the species here figured: you observe that the bristles of the abdomen are arranged in two rows. Counting the bristles in a limited number of specimens from one place, I find that the variability of the rows is as shown in the following table (in reality the range of variability is wider): the anterior row of the first dorsal segment of the abdomen has from 13 to 23 bristles, the second row from 8 to 10, and so on. The third paragraph gives the number of bristles of the individual figured (of the two sides together, the upper line referring to the tergites and the lower line to the sternites).

I	II	III	IV	V	VI	VII
		Abdominal Tergites				
13,8	11,12	10,12	8,10	8,10	7,10	5,7
23,10	19,12	17,12	16,11	17,11	16,10	16,8
		Abdominal Sternites				
—	2	2,7	4,8	3,7	4,8	3,8
—	2	7,10	8,10	9,9	8,11	13,11
		Individual figured (fig. 1)				
22,9	19,12	15,12	14,11	15,10	16,10	16,8
—	2	2,8	4,8	4,8	3,10	6,8

How many specimens would be required in order to be sure that there was a second specimen among them with exactly the same bristle-formula? The total is in round figures 14,482,000,000,000. I have not attempted to find this second individual. As a specimen is about two mm large, that total mass would cover more than 10 square miles. You will now understand why I have restricted the calculation to the bristles of the abdomen; for if we had taken into account also the variability of the bristles of the head, thorax, legs and modified genital segments, the total variability would be represented by such an enormous figure that there would not have been room for it on the slide.

Now, in many instances, and I expect in most instances, Nature does not produce all the mathematically possible individuals; but divides the series from one extreme to the other up into groups separated by gaps. Conspicuous di- and polymorphism, however, though common enough in insects, is the exception rather than the rule. Among fleas sharply marked dimorphism appartaining to both sexes is very rare; in fact I know only of one case, an Indian species (*Ceratophyllus punjabensis* J. & R. 1921), which is dimorphic in the shape of the head. A frequent category of variability is that in which the male is comparatively constant, while the female either is very variable or appears in two or more forms. Perhaps I may mention in passing that, if in a species of Lepidoptera one sex is di- or polymorphic, it is the female which is variable and not the male; this is not meant as a slight towards a section of this audience; the fact only shows the greater adaptability of the important sex. — Among the North American fleas there are several which come under this category of variability; they exhibit marked differences in the seventh abdominal sternite, a segment of much importance in the systematics of fleas. The figure of the tail-end of *Ceratophyllus asio* Baker 1904 (text-fig. 2) shows the position of this segment. The next figure brings the outlines of segment VII in seven specimens of *Ceratophyllus caedens durus* Jord. 1929 (text-fig. 3) from British Columbia, the apical margin of the segment varying from being entire to being deeply sinuate. The segment varies much less in the subspecies from New England. Pronounced dimorphism in this segment is likewise known in at least three species, one occurring in North America and two in Europe. The American species *Ceratophyllus petiolatus* Baker (1904) is found only in the Western States (text-fig. 4, a and b). When I came across these two kinds of females, I took them for specimens of two distinct species, and should probably have described the one on the right (b) as representing a new species, if I had not discovered a similar case among European bird-fleas (*Ceratophyllus styx* Roths. 1900).

With this example of variability, a phenomenon so very harassing for the taxonomist, we will close that chapter and turn to the question of

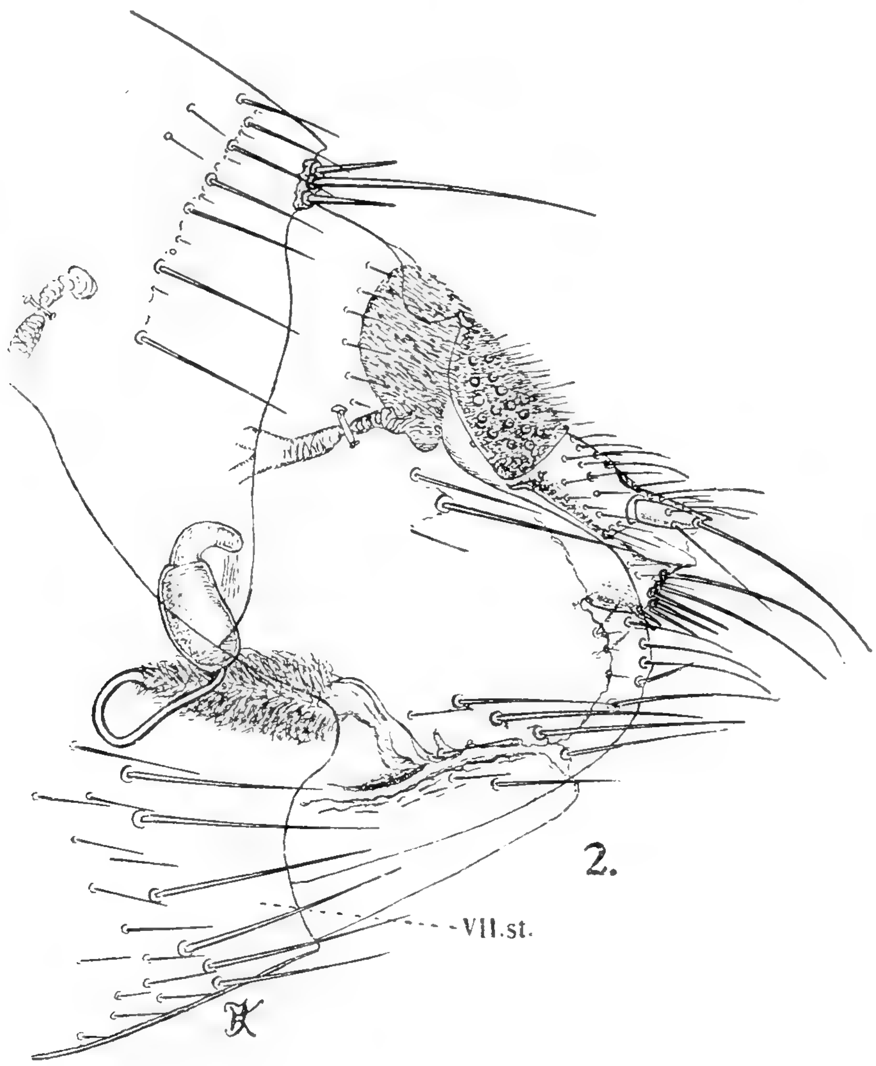
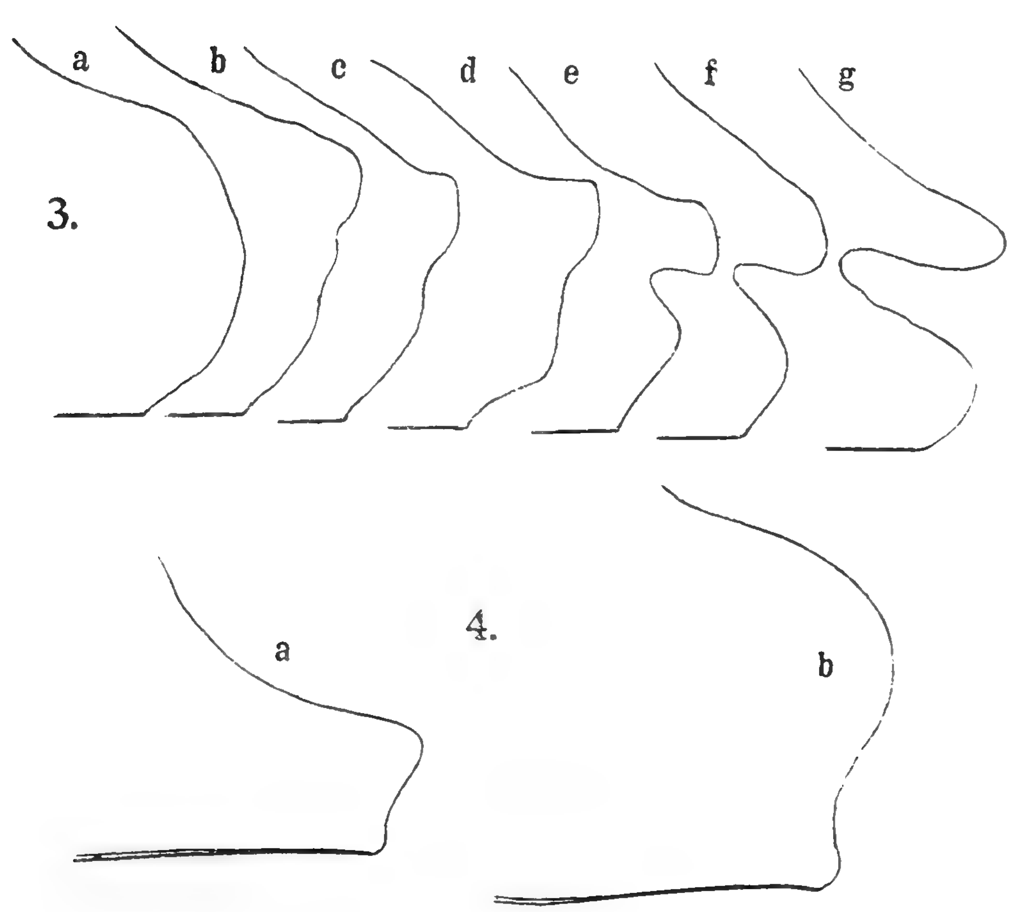


Fig. 2.

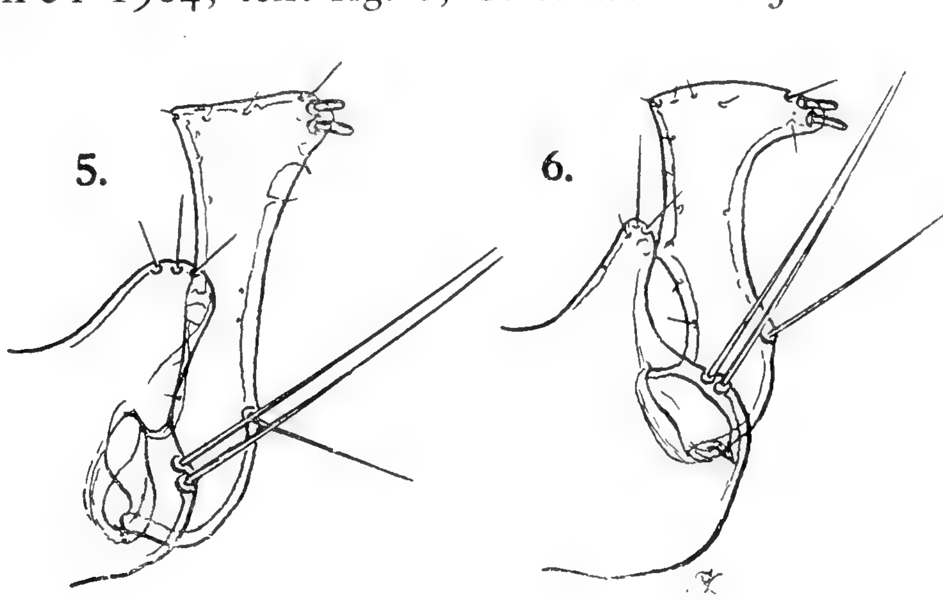


Figs. 3, 4.

variation. We may dismiss seasonal variation as unknown in fleas. Certain species are much commoner at one season than at another, but we have as yet no knowledge of differences between succeeding generations, and

I doubt that such seasonal differences exist at all in fleas. Geographical variation, however, in which the individuals of one district are different from the specimens of the same species in another district, is of very frequent occurrence among fleas, as it is elsewhere in animals.

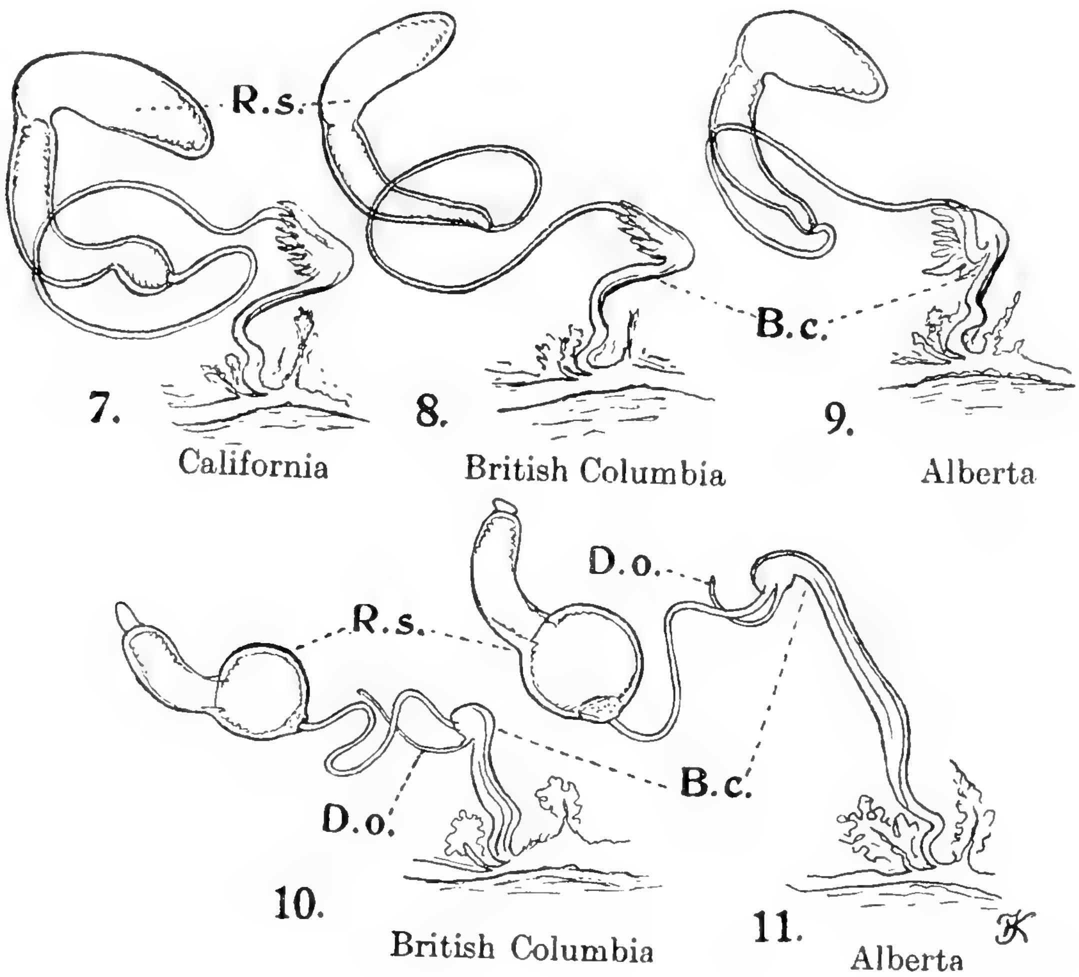
In geographical variation any and every organ of the insect may be affected. In fleas the distinctions between the geographically separated communities of a species are generally found in the external and internal genital organs. There are many fleas of wide distribution which do not seem to be split up by nature into geographical varieties. *Ceratophyllus penicilliger* Grube 1852, for instance, occurs from England over Europe and Northern Asia to Alaska and remains the same everywhere. Other species, on the contrary, are so susceptible that they are divided up into many subspecies even at comparatively short distances. And here again there is a remarkable difference between the East of North America and the West. None of the species restricted to the Eastern area have developed subspecies; they seem to be uniform from North to South. However, our ignorance of the flea fauna is great: if we had material from the Adirondacks and the mountains of New England for comparison with specimens from the Southern Alleghanies, which we do not possess either, a few subspecies might be discovered. Matters are very different in the West. Here many species are modified geographically: British Columbia, Alberta, the coast range of California, etc., each have subspecies of their own. The modifying factors seem to be particularly intense in the coast region of California, the fleas known from there being nearly all species or subspecies confined to that district. The characters which distinguish subspecies from one another are of the same kind as those which separate species; it is a question of degree, subspecies being incipient species. As examples I show figures of detail taken from specimens belonging to the coast subspecies and the Sierra Nevada subspecies (text-fig. 5, *Ceratophyllus c. ciliatus* Baker 1904; text-fig. 6, *C. c. mononis* Jord. 1929). Formerly



Figs. 5, 6.

one would not have taken any notice of differences such a you see here represented, even if they had been observed. But as science progresses, investigation becomes more and more penetrating. At first Entomologists were satisfied with desciptions of external characters, then followed the period of the study of the reproductive organs, and when these organs

fail to yield distinctions, the systematist will have to go down to the cellular structure of the internal organs. That is quite inevitable in the case of fleas where, in some instances, no distinctions have been found, by the methods of research now in use, between females whose males are widely different. Figs. 7—11 illustrate some minute subspecific differences; but we must by no means believe that taxonomists cannot penetrate farther. The figures represent a portion of the internal reproductive system of the females of two species. In the subspecies of *Ceratophyllus wagneri* which inhabits the coast district of California (fig. 7), the spermatheca (R. s.)



Figs. 7—11.

resembles a snake inasmuch as the end from which emerges the duct is somewhat swollen. This characteristic is present in all coast females of *C. wagneri,* whereas in the specimens from British Columbia and other districts the spermatheca gradually tapers towards the orifice (text-figs. 8, 9). The British Columbia specimens, however, are not identical with those from Alberta, for instance. The duct of their bursa copulatrix (text-fig. 8) is much longer, this distinction holding good in our series of specimens. The duct and the bursa together measure only two-eights of a millimetre in Alberta examples (text-fig. 9) and three-eights in specimens from British Columbia (text-fig. 8). It is no great jump from this point to the examination of the structure of the glands attached to the reproductive system.

Figures 10 and 11 are taken from another geographically variable Western species, *Ceratophyllus ignotus* Baker 1895; in examples of the same external size the spermatheca is larger in the Alberta subspecies (text-fig. 11) and the duct of the bursa copulatrix (B. c.) considerably longer than in specimen from British Columbia (text-fig. 10). The proportional lengths therefore, are just opposite to what we find in *C. wagneri* from

the same countries. Now, if the differences here figured between subspecies from Alberta and British Columbia have originated under the influence of the external conditions of life obtaining in the two districts, it seems quite clear that, as the result is opposite in the two species, the result must depend on the nature of the species. If you examine figures 10 and 11 further, you will notice that the blind duct (D. o.) of the Alberta subspecies (text-fig. 11) is absolutely, not only relatively, shorter than in the other subspecies (text-fig. 10); the long blind duct goes with the short bursa and the short blind duct with the long bursa. You see, evolution is a very complicated process.

The main object of this address is to stimulate research in Siphonaptera, and I trust to have made it clear that there is still a large field in North America for new discoveries and that the problems touched upon await further elucidation. If as pure entomologists we perhaps deplore that the West is so much richer in species and that these have a much wider range of variability and variation than in the Eastern States, there is from the point of view of the applied entomologist this consolation that fewer Ectoparasites also mean fewer potential carriers of diseases.

On the Splitting Influence of the Increase of Entomological Knowledge and on the Enigma of Species.

Walther Horn, Berlin-Dahlem.

(With 6 Text-figures).

I will speak about the splitting influence of our increasing knowledge. I refer to the fact that in every branch of science and commerce the time arises when the bulk of knowledge becomes too great for a single human brain to hold. Is that really a splitting influence? I believe "not"! Splitting denotes a breaking up of continuity and therefore a loss of power follows. Division of work by specialisation leads to concentration and gives a higher result! Can we note in this sense a splitting influence in entomology since Linné? I believe "yes"!

1. Has a wedge been driven into the whole block dividing it into 2 parts?

2. Has the danger come that one of the foundation pillars of entomology has been split?

I. The question of work in the different entomological branches! Everybody knows the contrast between the trained scientists and the untrained ones; notably amateurs. All of you know how the splitting has come about historically. The amateurs have almost all taken the side of taxonomy. The scientists have always more and more withdrawn from it, although they are still distributed throughout all branches. Just in the same sense possibilities are being laid for training in Europe. In the European colleges there is place only for courses for biological or experimental branches, while taxonomy has fallen under the table almost everywhere. Parallel to it goes the meager qualitative and quantitative supply of taxonomists: the fact they are little esteemed and therefore their little chance for a career. The amateurs have done an enormous work, but long since taxonomy has become too big to allow spirit, diligence, and good will to be sufficient. It is the broad basis of knowledge which is now-a-days too often lacking in the amateurs. Long since the amateurs have tried to keep their place through specialization, even by very narrow specialization. Long since the time has come when they are hardly able to hold on, as the connection with the neighbouring branches of science has become lost. There has come a certain danger in place of the original help.

II. The subject studied! The anatomical and physiological branches lay the subject more or less aside after having studied it. It becomes only occasionally of simple historical value. Taxonomy often lays on the subject itself even a higher value than on a work written about it. What cult of types is existing at the present day : over 120 names! What endless obstructions does the science suffer from them: getting even sometimes almost entirely locked up. The object remains for taxonomy often a good

deal of the final aim. It is for the other branches only a transitorial means of accomplishing the aim.

III. The aim of taxonomy is not only for scientific work, but also the principle of ordering; that of the other branches research with the aim of establishing laws and principles. The result of taxonomy is too often only to be understood by the specialist or the knower of the subject, while the result of the other branches is self explanatory and becomes therefore later on simply an axiom for further studies.

IV. The influence of the historical method. The thinking of taxonomy is based at the same time on history and natural history, that of the other branches is working only in the sense of natural history and the point of view of history becomes then only of academic interest. A further consequence of it is that errors in taxonomy continue often for eternity in the literature, although they have been recognized; while the other branches simply pass them by after recognition. That is why the bibliography of taxonomy rolls up like a snowball, especially as it is standing under the curse of returning to the original source even if it goes back to 1758, even if the earliest description were a riddle. There is no help in cancelling as the other branches do automatically by using the last publication as the final word. The difficulties, even impossibilities of giving short abstracts of systematical results doubles the unfortunate situation of taxonomy.

V. The qualitative factor of the working method of taxonomy! Taxonomy gives descriptions of animals, but it restricts them consciously or unconsciously to the rudest indications, often only to differencial-diagnostic ones. From the stand-point of comparative anatomy all these descriptions would be quite insufficient. Everybody knows that Linné could have said much more about the anatomy of his species than those few words in his lapidary style. In all other branches such a working quality would be thought crude and careless. On the other hand the description of species would have become a shoreless sea, if we had followed the exact method of the other branches. He gives, so to say, only quantitative descriptions of animals, not qualitative ones. It is only applied comparative anatomy. The taxonomist employs chiefly negative deductions as the method of describing a species, as they are in the last instance establishing missing links, while the other branches try to give a positive, even experimental proof.

So I believe that entomology has become split. Taxonomy is standing for all these reasons alone on the one side; the other branches on the other.

Now the second chief point: Has taxonomy split its foundation pillars? Opening this question I will restrict myself only to fundamentals, the conception of species, as only descriptions of species are objective; from the genus on everything becomes relative-speculative. 150 years ago one of the great Danes wrote the majestic words on the firmament of the entomological heaven: "*(species) si pereunt perrit et cognitio rerum, (species) si confundantur, confundantur omnia necesse est.*" Linné described his species and genera (which we would call to-day "families") in the most lapidary style, using so to say almost only the rudest comparative anatomy, applying it to bring order. Thus everything was lying, so to

say, in one horizon. Then the theories of evolution started, at first (although in the rudest form of bastardation) the genetics. All other well-known "ologies" followed, especially the most dangerous of all: phylogeny; pathology with its agglutination, precipitation etc., was added, pure chemistry was the last to appear. The future will bring the intra- and extracellular symbioses. Every branch brought a new point of view. Don't forget that palaeontology has used prints, even foot prints alone, even holes alone (the description of many so called amber-species) instead of actual remains. Don't forget that phylogeny and palaeontology are vertically directed thought, the others horizontal.

How often have biologists been amused by the idea that one could study the question of species by means of dead bodies. And t h e i r explanation of species? Where is it? The believers might have generally consoled themselves with the idea that taxonomy might become one day a kind of an extract of all other "ologies", the results of which might cover one another like congruental triangles, of course with the generally allowed limit of errors. In reality we have forgotten more and more to ask: what i s a species?

What did the taxonomist of the old Linnean school do? Most of them continued quietly to describe further species and further genera. The first duty of all so-called distinguished taxonomists should be to give in their work a final resumé of their interpretation of species! In practice most of the taxonomists follow the rule that, 1) they either interpret the species as artificial products of the human brain: "only individuals exist"; or 2) they describe species and try to force them into a scheme of descriptions combining them in form of genera to higher unities; or 3) they negate species by only believing in gentes; 4) there are still some employers of the empirical method who claim that a good taxonomist could divide most of species in a clear way, although the difficulties could vary very much in the different groups and for a certain remainder it might happen that species could not be divided at all in a sharp way: depending on the larger or narrower experience of the respective taxonomist!

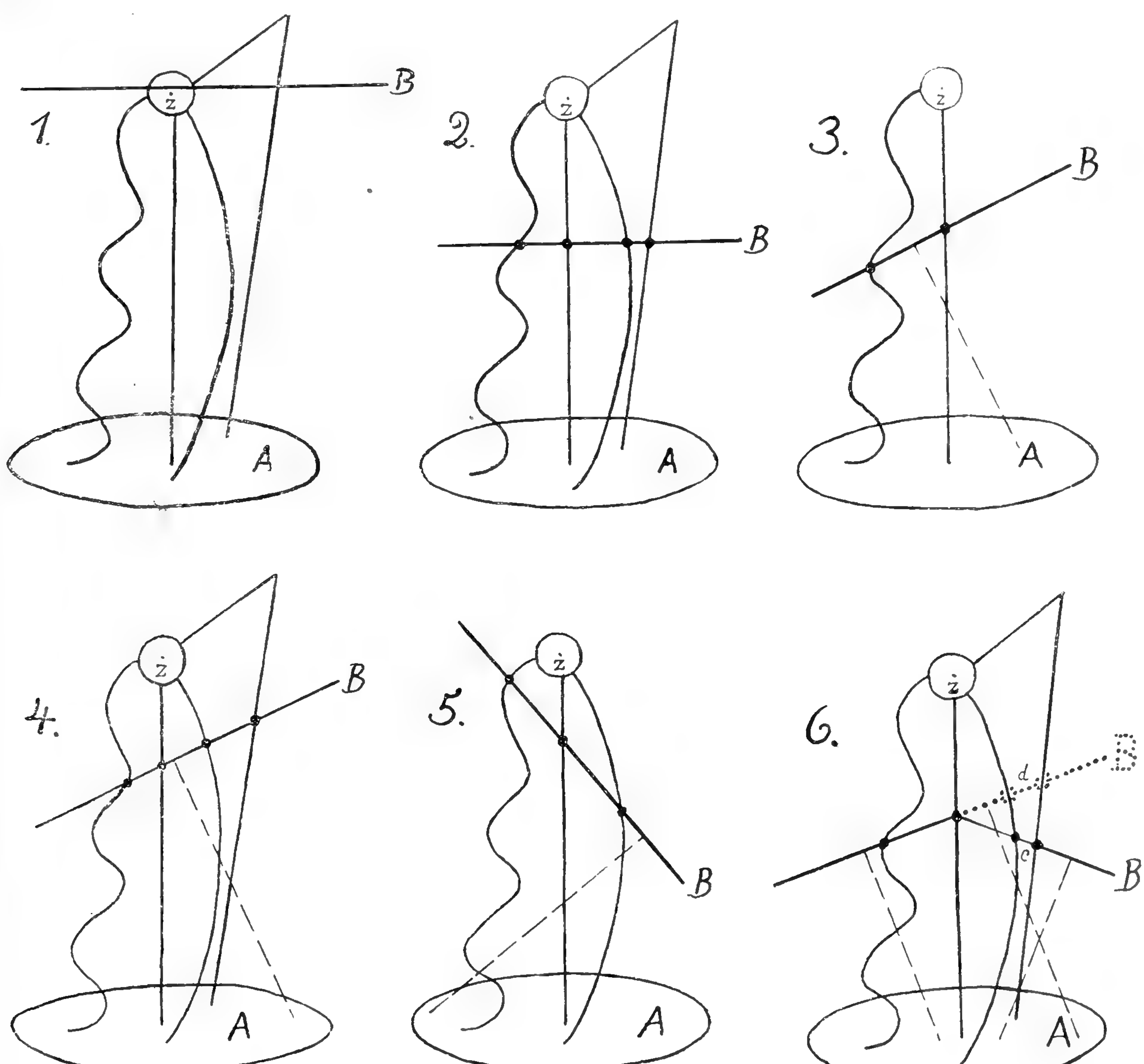
And the consequence? The curve of the number of species is crossing the line of our acknowledgment of the problem of species. This situation has become in some way grotesque, as entomo-taxonomists have published twice as many so-called species as the rest of zoology and botany together. Is there perhaps an inner reason between the endless roving descriptions of species and the loss of our native harbour, the problem of species?

And the general zoologists? Most of them smile at the dusty idea of species. And the men of the liberal arts? Well, in all probability they might be astonished, asking: Has your science still a right to existence when your ground pillar has become long since shattered? Is that not perhaps even more than splitting?

The enigma of species. What i s a species? Since decenniums we ask almost only: Where is the steamer running from and who is the steersman? The question of the future might be: How is the steamer running and what is its cargo? I don't ask where the species is coming from, I let it come and let it go, I am only asking for the actual horizon of the species. The species is built up by unity of its aims, it means by the

union of the different evolutionary branches of its single components. Only 2 points are necessary: Aims directed convergently, they might even run in a not chronological way. Is the existence of species a negation of evolution? I answer: "no!" Species are serving only as rests, as pauses in the respiration of evolution. So I am formulating the word: enigma of species.

We know that the anatomical characters of a species don't develop absolutely equally. The curves of the development of size, sculpture, etc., can cross one another in different ways, even the development of external genitalia can become independent from that of the interior ones. There is not at all a strong parallelism between the systematical characters and the geographical distribution; still less between them and physiological qualities. It is not at all necessary that the development of characters of a species run synchronically for anatomy, physiology, phylogeny, etc. Certain characters might go with full speed ahead, others might follow slowly, others even by atavistic round about ways. We might illustrate all these questions by the following figures:



A signifies the plane of thoughts of the respective taxonomist. Z gives the terminal aim of the development of a species, the components of which are represented in our figures only by

4 lines of direction. Each of them shows a ball which represents the actual resting point just reached in evolution. The 4 lines might illustrate the animate and inanimate powers or the branches of one single group, e. g. anatomy, which are building up the species. One direction goes a straight way, the second a slightly curved line, the third a regularly undulating line, the fourth shows a round about way. B gives the actual plane or horizon of the species. In figure 1 you will see the terminal aim of species is reached. Its 4 componental lines meet each other in one point. The actual horizon (plane B) of this species laid through it (in this case the horizon of the terminal development) could be fully surveyed from every stand-point of the plane B. — In figure 2 we see the same situation, only we don't have before us a terminal species. The 4 branches of development have run not chronologically but allow the construction of a horizon (the actual plane of the species) through their resting points. The survey of the species is therefore as clear as in figure 1. — In figure 3 we always see 2 directions of development running identically in space and time; thus twice 2 synchronous developments; we see thus only 2 lines of development, both not synchronous one with another. The horizon of the species laid through them is running in an oblique direction and one needs patient trying from the stand-point of A so as to get a full survey of the whole plane of the species, but the specialist will finally succeed in discovering the vertical optic angle to B and so clear up the species. — In figure 4 we have the same relations; only all directions of development are running dyschronically, but by a happy chance it is possible, although with difficulty, to construct from A an optic angle so as to survey the whole plane of B. — In figure 5 we have altogether only 2 lines of development running identically in space and time. Thus we have altogether 3 directions of development running not synchronous one with the other. As it is always possible to construct a plane through 3 points, the construction of the respective plane of the species is under these circumstances easily possible, but it is very difficult to find from the position of the taxonomist A the right optic angle to survey this whole plane. Not very many taxonomists will be able to find it. Thus the best authors can disagree. — In figure 6 we see one of the great difficulties: 4 lines of direction, no one running synchronous. It becomes impossible to construct one plane through all these 4 resting points. The consequence is that no taxonomist can fully survey this whole plane B from one and the same stand-point of A. He cannot do so, as the plane has become wavy. If in the course of later evolution the point c will reach d the construction of one horizontal plane would become possible again and all taxonomists could agree again in their interpretation. In reality millions and millions of directions of development are running together instead of those 4 supposed in my figures. I will now illustrate for you all these ideas by a little model I have brought with me. The conception of species in all these ideas would be the resultant of more or less parallel and convergent lines, but not synchronous ones of anatomy, physiology, genetics, chemistry, physics, etc. You might protest! In spite of it, please allow me to carry these ideas a little further. Let us agree that they have to illustrate the difficulties only in a symbolic

way, as other conceptions might not be possible. You might call my ideas in some way pathological ones, but remember that microscopical slides of pathological brains can explain the normal brain. You might even believe me to be ripe for Bloomingdale!

There is no longer a boundery line between chemistry and physics: chemistry has become a chapter of physics! How often have we doubted a boundery line between chemistry and biology! Let us construct for one minute the metaphysical bridge between materia and life as has been so often tried. Let us compare the notion of biology and chemistry. The difference between a plant and a chemical product is surely greater than the reciprocal between a plant and an animal, but also the inanimate matter supposes invisible atoms, ferments, antibodies. Let us think of the notion of isomery, metamery, polymery, isomorphy; let us think of synthetical construction in a metaphysical sense. What would be the chief point of difference? I think the instance that in the inanimate world all these principles are synchronous working one with the other (the same experimental result identical everywhere under the same exterior conditions), while the peculiar feature of the unknown power of life is given by the fact that the single features, although inseparable in space, might run separately in regard to time (a higher resistance of living species by inner power against the same external influences). I don't claim these ideas to be new ones, although they might seem to be a little phantastic and mystic for some of you at the first minute: from the causal-analytic stand-point the notion of species will never be attained. Let us imagine the species for a minute to be symbioses between the animate and inanimate world, symbiontic isomeries or isomorph biocoenoses, as chemistry come to life, as living physics. Let us imagine that the geneticist builds up species synthetically, let us imagine that the creating energy which we adore under so many living and unliving forms has created the species synthetically from the different directions of development coming from all these sources. Let us homologize the notions "phylogenetic" with "isomere", "synthesis" with "phylogeny", "gene" with "atom", "synonym" with "isomorph". I know very well that most of the taxonomists will reply: "synonym" means "identical", but that is not right. If 2 variations are synonymous, one might reach in one country 95%, it means of a 100 specimens of the general form 95 belong to the respective variation, in another country only 40 that proves a great difference in geographical or genetical fixation. I draw your attention e. g. to the reciprocal occurrence of *Cicindela scutellaris nigrior* in the South-eastern states of your country and its sporadic occurrence in this state.

I am comparing species with isomere formulas of chemistry, as all those thousands and thousands of crossing lines of evolution which are creating the species, produce for our eyes a more or less identical anatomical picture or at least a picture which allows from the rudest point of anatomy identical conceptions. — I am comparing species with isomophical chemical matter, as the same taxonomical species can show quite different features in the different biological branches. In both these comparisons the rudest anatomical formula of the old taxonomic school of Linné might be the point from which we have to start for investigating finer formulas of structure for every species.

You might protest! Allow me in spite of it to follow such speculations a few minutes. Let us compare an animal species with certain phenomena of disease with convergent symptoms, i. e. isomorph phenomena of diseases as e. g. the typical polyphyletic symptoms which we call dyssentery. This complex of symptoms may arise from a dozen different causes: bacteria, amoebae, chemical poisons, uraemia, sepsis. In most of the cases it is a simple thanatocoenotic complex between men and bacteria, respectively amoebae, but we know that occasionally cases occur where the thanatocoenotic events become biocoenotic ones, it means a symbiosis arises; men become carriers of bacteria. Can we imagine that anatomy, physiology, genetics, chemistry and physics can be coupled not in an identical but in a comparable way? Dyssentery would be in this sense an isomorphic disease, a polyphyletical complex of symptoms with identical *pathological* mirror. The species would become a complex of components with identical *anatomical* mirror! Don't be afraid when I continue these comparisons: From the imaginary conception of isomorphic species we would come at last to the possibility of a polyphyletic origin of species and genera. Are species resembling words of languages of mankind: steady but inspite of it slowly flowing? I believe not! They resemble more notions of logic dependent on the actual time of the reviewer.

What would be the practical consequence of all these theoretical speculations? We only need to draw a comparison with the practice of the best known biological science: medicine. The practising physician has to make diagnoses which seem to be crude. Also for him the so-called intuitive method plays a large role, the intuitive method which is really the combined result of experience and knowledge. Of course the practising physician cannot always make a correct diagnosis, also he depends often largely on specialized branches, ex parte the same which taxonomists need, e. g. physiology, biochemistry, biophysics. Nobody can contest the fact that the practising physician in spite of all these difficulties very often makes his diagnosis in an astonishingly correct way, although feeling sometimes helpless. He may, if he has doubt, ask the help of other branches. In the same way the taxonomist might interpret his business from the stand-point of crudest comparative anatomy by separating his species, by finding or negating missing links, profiting by characteristics empiristically found, by keying, cataloguing, etc. In a similar way he compiles his faunas and clears up the synonymy of doubtful descriptions and interprets taxonomical differences which seem to be similar at the first view. Don't forget that even under the supposition of this narrowed taxonomic horizon the powers and nerves of taxonomists have already become much overstrained. All living taxonomists of the world have not been able to survey the one actual horizon of comparative anatomy. A further overstraining would lead simply to a greater splitting. When we are running behind 20 hares, we hardly catch one! I fear from all the "ologies" which the poor taxonomists have to know, taxonomy goes to the devil. I beg you not to conclude from these words that I recommend taxonomists consciously neglecting all these "ologies". The shoe-maker can learn from the technic of a tailor, but he has by doing so not to forget his own shoe-maker work.

I don't fear the objection that the taxonomy of the old Linnean

school has outlived itself, as e. g. anatomy and histology have done decenniums round after having finished their most primitive duties, benumbed by the sudden shock of the modern experimental research. The immeasurable millions of species of insects would give still primitive work for centuries. You might protest against the 4 theses stated here by me; they are: 1) Taxonomy is not identical with anatomy; it is only applied comparative anatomy. 2) Taxonomy is not identical with entomo-museology; it is only theoretical entomo-museology. 3) Entomo-Museology is applied Taxonomy. 4) Taxonomy does not need to be bound by phylogeny. It is not its child but only one of its sisters: Analytic explanation of characters and phylogeny are not the same!

And the enigma of species in the last instance? I don't believe the riddle will be solved by pure natural history alone. Although we have approached by the air-line; the remaining distance shows a narrower but a deeper abyss. The idea of species will continue in the last instance for ever as a heuristic problem of metaphysics, from which we might receive some profit by adoring it as a veiled picture of a deess like the "power of physics. If one calls the work of taxonomists unlogical because they have an unclear basis, I would answer smiling: Can you define the conception of the species "man"? Yet in spite of it what monuments are built up on this ground! If here and there sometimes one of the other branches has thought it could solve finally the notion of species, it has always proved a mirage. Don't forget: the final clearing up of the notion of species would be nothing else than finding not only the actual tree of life, not only its roots, but even its seed-kernel!

In spite of it I claim: The human brain needs pictures for remembrance. The human eye cannot see physiological, genetical, etc., laws directly by the binocular of its brain, but only via anatomical illustrations and interpretations. The power of life cannot be analized by chemists in their retorts, cannot be cut by the microtome. Only comparative anatomy can give correct pictures of those sometimes slowly, — sometimes fast passing — pauses in respiration of evolution which we call species. Only anatomy can register those states of benumbedness in the development of all these parallel but not synchronous symbiontic couplings between materia and power of life. Only the binocular of metaphysics can finally understand these couplings. That is why the old Linnean school of taxonomists has also for the far future to polish the spectacles through which the other branches have to look, if they would like to get an idea of the millions of insect forms. Do not forget: the human eye is the surest port, the safest harbour for the remembrance of mankind.

The immeasurable bulk of insect species seemed once to abolish taxonomy. Its last escape might be perhaps the failing of the other branches, for which reason taxonomy becomes again a necessity. Linné immortalis!

I am finishing, Ladies and Gentlemen, but please don't ask me what I think myself of symbiontic couplings of materia and powers of life, physiology, genetics, chemistry, physics. Smiling I would give the answer: Go to the geneticists: they are studying bastardations. We happy taxonomists have a right to say: **ignoramus**!

The Japanese Beetle, its present Status and Control.

Loren B. Smith, Bureau of Entomology, U. S. Department of Agriculture, Moorestown, N. J.

Introduction.

When an insect is introduced from a foreign country and established in a new environment, certain questions confront the entomologist which may be difficult to answer. Will the introduced insect become a pest of economic plants? Will it find climate and breeding conditions favorable for its multiplication? Will it be attacked by parasites native to the country into which it has been introduced? These were the questions which had to be considered in the case of the Japanese beetle, which was first discovered in the United States in 1916 at Riverton, New Jersey. The literature contained relatively little information concerning the insect beyond indicating that *Popillia japonica* Newman occurred generally throughout the islands of the Japanese Empire, but was not considered an important pest. When the beetle became established in the United States, however, it soon developed that this insect was capable of causing serious losses to many economic crops and plants, that it had found ideal conditions for its multiplication, and that there was little evidence that it was being attacked by any parasites native to this country.

After considering the information obtained during the summer of 1917, it seemed advisable to Federal and State authorities to undertake cooperative work leading towards the extermination of the insect. Actual work along this line was begun in the summer of 1918. At that time an effort was made, during the period when the adult beetles were present, to maintain continuously a coat of poison on the foliage over a strip aproximately one-half mile wide entirely surrounding the infested territory. The maintenance of a coat of poison on food plants growing along the road-sides was also attempted in order to keep the beetles away from the roads and reduce the danger of their further distribution on vehicles passing through the infested territory. Hand picking of the beetles on a large scale, in the central area purposely left untreated, resulted in the destruction of somewhat more than four bushels of the adults. During the autumn of that year approximately 17 acres of ground were treated with a solution of 165 pounds of sodium cyanide in 12,000 gallons of water per acre. The same general program was continued in 1919 and 1920 with the addition of a plan for the destruction of non-economic plants along road-sides, fence-rows, and in other uncultivated places. At the close of the summer of 1920 it was evident that, although the dispersion of the insect toward the south and west had apparently been lessened,

it had spread considerably toward the north and east. A study of the situation revealed that extermination or even satisfactory control had not been secured and probably could not be obtained with any reasonable expenditure of public funds The increase of the beetles and their spread during later years has fully confirmed that early conclusion.

Dispersion.

Japanese beetles are strong and vigorous flyers, capable of travelling several miles in a single flight. They have been carried accidentally in motor cars, trucks, trolley cars, and railroad trains, and thousands of beetles have been removed from farm produce, the movement of which was regulated by quarantines. The ability of the insect to fly and its accidental carriage in vehicles and trains have accounted in a large measure for the rapidity of its spread throughout the Northeastern States. While the beetle is now known to occur from Maryland to Massachusetts, it is not uniformly distributed throughout this territory. The heavily infested area includes 800 square miles in central New Jersey and eastern Pennsylvania, where the insect has been established for the longest time, and where it is sufficiently abundant to cause injury to various crops. Outside the central, heavily infested territory the occurrence of the insect is more or less sporadic and, for the most part, confined to towns and cities.

It is known that the Japanese beetle is capable of feeding upon a great variety of cultivated plants, although most of the preferred species are hydrophytes and mesophytes. This being the case, it must be assumed that its spread is favored in sections where hydrophytic and mesophytic vegetation prevails, whereas it is reasonable to suppose that it has been stopped, or at least retarded, in sections where xerophytic plants are dominant. The food requirements of the larva are best met in soils with a generous covering of herbaceous vegetation, particularly where there is a permanent or semi-permanent sod. These conditions are amply met in the region where the Japanese beetle now occurs.

As an indication of its abundance, it has been found that the larvae have averaged 175 to the square yard during certain seasons in 2,833 square yards dug in 652 fields and pastures throughout the heavily infested area. Evidence has been accumulated recently which indicates that the species is somewhat less numerous in the older occupied areas. This is probably accounted for by a combination of factors, including the general use of insecticides developed for plant protection, the presence of introduced parasites, and the general increase in the numbers of soil organisms pathogenic to the larva under certain seasonal conditions.

Food habits of the adult.

Over 250 species of plants have been recorded as furnishing food for the Japanese beetle in the United States, including almost all of the economic crops grown in the infested territory. Between 25 and 30 species, however, constitute the preferred food plants. These include apple, quince, peach, cherry, plum, grape, blackberry, clover, soy bean, and corn. The shade trees included in the list of preferred food plants are linden, birch, white oak, elm, horsechestnut, willow, and sassafras. Many ornamental shrubs are seriously injured at times.

The Japanese beetle is most often seen as well as most injurious in the adult stage, by reason of its active habits and the injuries it causes to foliage, flowers, and fruit. The injury to foliage is most conspicuous and characteristic, being comparable to the eating done by leaf chafers. The leaves are usually skeletonized, and, when severely eaten, they turn brown and drop, thus bringing about defoliation. Since the beetles prefer to feed on foliage exposed to the direct rays of the sun, they do not usually entirely defoliate the larger shade and timber trees. They commence to feed on the upper and outer foliage and work downward, and by the time one-half or two-thirds of the foliage has been consumed, they usually leave, and congregate on other plants. Such injury does not appear to affect the health of the trees immediately. When such feeding continues year after year, however, it may result in the death of many fine and valuable ornamental trees.

Fruits which ripen early in the season are most subject to the attacks of the beetles. By actual count, 87 % of the fruit was destroyed by the Japanese beetle on certain peach trees of the Rochester variety, and as many as 5 bushels of apples damaged by the beetles have been harvested from a single tree of the Yellow Transparent variety.

Injury to developing ears of corn has been severe. The seriousness of this injury, involving, as it does, one of the great staple crops of the United States, cannot be overlooked. The beetles are fond of the green silk and the developing ear; they congregate at the tip, cutting the silk off close to the husk, and feeding on the developing kernels at the tip of the ear.

Food habits of the larva.

The feeding habits of the larva have been found to differ somewhat from those of certain of our native species. The larva forms a cell in the soil and feeds on the fine rootlets at the top and bottom of the cell, usually following the course of the rootlets until they are consumed before attacking others. It is this habit of feeding which has prevented injury to grass from being extremely serious, since it is only in areas of heavy infestation that many plants have been found that had all the roots destroyed. It also follows that the injury has been most noticeable and severe in areas which suffer from drought.

Life history of the insect.

The Japanese beetle has one generation a year. The adults begin to emerge between the 10th and 15th of June and are present until the middle of October. The female beetles each lay between 40 and 50 eggs in the soil. The eggs are laid separately, three to five at a time, about two to four inches below the surface of the soil, and the egg laying period is usually four to five weeks in length. The eggs hatch in 9 to 15 days, and the tiny larvae become full grown in about six weeks, at which time they reach a length of approximately one inch, and resemble the larvae of *Phyllophaga* in appearance. As a rule, they feed one or two inches below the surface. As cold weather approaches in the autumn they descend to an average depth of about seven inches, where they pass the winter in a quiescent condition. In the spring they again become active, and move

upward toward the surface of the soil, where they feed for about a month. By the latter part of May or early in June they transform to pupae, and appear as adults two to four weeks later.

The Problem of Control.

Enforcement of Quarantines.

The early realization of the potential danger from the Japanese beetle led to the inauguration of a quarantine in 1918 by the New Jersey Department of Agriculture, and since then quarantines have been maintained by the Federal Horticultural Board (now the Plant Quarantine and Control Administration, of the U. S. Department of Agriculture), the State of New Jersey, and, later, by the States of Pennsylvania, Delaware, New York, and Connecticut. The first quarantine covered only green, sweet, or sugar corn, as at that time this was believed to be the commodity most likely to carry the insect to points outside the infested area. The regulations have been changed from time to time to meet the changed conditions brought about by the extension of the infested area and the increase in the density of infestation.

For the season of 1928 the movement of all farm products, with the exception of certain root crops and dry seeds, and all nursery stock, sand, soil, peat, compost, and manure is restricted. It has been considered that restricting and safeguarding the movement of nursery stock and other plants is perhaps the most important phase of the quarantine work. These efforts, so far as known, have entirely prevented the distribution of the insect with nursery products during the ten years of quarantine. The risk of spreading the insect with such stock is due principally to the possible presence of larvae in the soil about the roots. There is less danger of distributing the adult Japanese beetles with nursery stock, because little of this stock is moved in summer when the adult beetles are present.

The quarantine on nursery stock and soil is effective throughout the year. Several years ago certain chemical treatments of the soil were accented in lieu of its removal and the actual inspection of the plant roots. The policy was adopted that, providing treatments were found which would entirely free the soil from infestation, plants with soil about the roots might be certified for shipment after such treatment had been applied. It then became a problem of devising methods for treating soil which would give a complete kill of the larvae without injury to the plants. At the time these investigations were undertaken, little was known concerning the treatment of soil to meet such conditions, and much preliminary work had to be done before methods were devised which would serve the purpose. As a result of these investigations the use of dilute carbon bisulfide in an emulsified form was developed as a treatment for balled nursery stock. During the past year more than 150,000 plants have been treated by this and other methods now employed, before being shipped to points outside of the area infested by the Japanese beetle. Deciduous trees and plants which can be shipped free from soil must be washed before the roots can be inspected. A large amount of this type of stock is cleaned each year under the supervision of Federal quarantine inspectors.

During 1927 76,155,423 nursery plants were certified for shipment out of the regulated area. These were distributed in the 48 States, Canada, Mexico, and many foreign countries. There were also shipped from the regulated area 10,206 carloads of sand or soil, consignments being made to all of the States and to Canada. In addition, 5,905,021 packages of farm products, 55,507 bales of hay and straw, and 25,279 boxes of cut flowers were inspected and certified for shipment from the regulated area.

As a means for determining the spread of the Japanese beetle from year to year, scouting crews are located in the territory adjacent to the periphery of the known infested area. It is their duty to search for infestations in assigned territories at regular intervals during the summer. Upon finding beetles, the scouts are moved farther out from the district where the infestation occurs. In this way a fairly accurate idea is obtained of the annual extension of the area infested by the beetle.

Control of the Adult Beetle.

The adult Japanese beetle prefers those varieties of fruit which ripen early in the season. Attempts to protect apples and peaches from attack by the beetle by the use of lead arsenate at the rate of 1½ pounds to 50 gallons of water were unsuccessful. When the dosage was increased, and powdered lead arsenate was used at the rate of 3 pounds to 50 gallons of water with 2 pounds of flour added, good results were obtained on apples. This spray could not be used on peaches without danger of injury to the plants. Although it was found that lime, chalk, lead arsenate, or other white materials applied to the ripening fruits repelled the beetles for a short time, the repellent effect of the materials other than lead arsenate disappeared in a short time. As yet no means of protecting raspberries and blackberries or the blossoms of flowering plants has been devised, as the beetles avoid the sprayed foliage and cluster on a ripe fruit or on an opening flower bud.

During the early experiments, it was believed that the size of the particles of lead arsenate might have some effect on the amount of the poison consumed by the beetles. A colloidal lead arsenate was prepared which gave a slight increase in the number of beetles killed. A material known as lead oleate-coated lead arsenate, developed about five years ago, is a composition of lead arsenate paste and lead oleate. This coated lead arsenate has been found extremely useful in the protection of ornamental plants and of nonbearing fruit trees. The lead oleate serves as an excellent sticker and spreader, and one application of this material to the foliage in June will remain effective under usual conditions throughout the following six or seven weeks. A green lead arsenate has been devised which is eaten more readily by the Japanese beetle and which kills a large proportion of the insects coming to the sprayed foliage, but it does not afford the protection to the plants which is obtained by the use of the oleate-coated lead arsenate.

The habits of the beetles in congregating on plants in large numbers suggested that contact sprays would be useful as a means of control. It was found that a neutral soy-bean-oil soap made a very desirable contact spray. Later studies revealed that the insecticidal value of a soap is

directly dependent on the strength of the film formed by that particular soap, and it was finally discovered that a soap prepared from a coconut fatty acid had the highest toxicity of any of the common soaps. To increase the insecticidal value, small quantities of oleo-resin of pyrethrum and of sodium silicate are added to the coconut-fatty-acid soap. This preparation is now on the market and is quite generally used where a contact spray is desired. It has also been found that this combination of materials is very effective against the striped cucumber beetle, *Diabrotica vittata* Fabr. and the harlequin cabbage bug, *Murgantia histrionica* Hahn, which, up to the present time, have been difficult to control.

In order to obtain a higher kill by the use of arsenicals it was believed that if some attrahent was combined with the lead arsenate it would cause the beetles to consume larger quantities of poison. The search for such a material began with a consideration of the favored food plants of the beetle, and with tests of their essential oils. It was soon found that the essential oils of sassafras, clove, apple, peach, and cherry exhibited certain attrahent properties. Geraniol, one of the higher alcohols commonly used in commerce as an ingredient in perfumes, was found to be extremely attractive. Few, if any, other insects have been found to be attracted by this chemical, and it is apparently a specific for this insect. The combination of geraniol with arsenical sprays has not been altogether successful. It is possible to keep the beetles on the sprayed trees for a short time, but the increase in the kill is not very great. At the present time geraniol is used as a means of concentrating a large number of insects on a few plants where they may be killed with a contact spray.

Traps of various types have been developed and are now in general use. Geraniol is used as the attractive constituent in the bait. Though the traps have never caught more than approximately 33 per cent of the beetles within their vicinity, it is believed that improvements in design will make them much more effective as a means of control for the Japanese beetle.

Control of the Larva.

In our studies on the control of larvae in the soil, we have had to consider the problem from two viewpoints. The first was of the treatment of soil about the roots of plants and nursery stock, which contemplated the *extermination* of any infestation which might be present in the soil. The second was that of the treatment of turf on golf courses and lawns. In the latter case control was sufficient, and it was not necessary to obtain extermination. Considering the treatment of soil about the roots of nursery plants, it is evident that the method must be certain to kill any stage of the insect and yet must not injure the plant. A study of many hundreds of compounds failed to reveal anything superior to carbon bisulfide for this purpose. The soil absorbs a relatively small amount of the chemical, and, by using a sufficient quantity of water, penetration to a depth of 24 inches can be obtained. Several emulsions of carbon bisulfide have been developed. The qualifications for a suitable emulsion for use on nursery stock are that it will not stratify or break down upon standing, that it will not be affected by temperatures as low as 35° F, that it will not foam and thus make it difficult to measure it accurately, and that

the concentrated emulsion can be produced in such a way that a standardized product can be obtained. A recently developed miscible carbon bisulfide has most nearly met the various qualifications for a good emulsion. This is prepared in a concentrated form which contains approximately 70 % of carbon bisulfide.

The concentration of the chemical necessary for control in the diluted treating solution depends upon the temperature of the soil to be treated. No treatments are made when the soil temperature is below 40 ° F. When a plant in a nursery is to be treated it is surrounded with a galvanized iron strip bent to form a collar and pressed partly into the ground. This strip should be approximately nine inches wide and of sufficient length to include an area 12 or 18 inches wider than the prospective soil ball. The dilute carbon bisulfide emulsion is then poured into the enclosure thus formed and is allowed to percolate about the roots of the plant. The soil is left undisturbed for a period of 48 hours, at the end of which time the plant is dug and shipped.

During the past two years the use of water at a temperature of 110 ° to 114 ° F has come into general use as a means of treating those types of perennial plants which are shipped without a ball of soil on the roots. Under usual conditions a treatment of 112 ° F for a period of two hours is sufficient to kill any Japanese beetle larvae about the roots of such plants as dahlias, peonies, iris, phlox, blueberries, and many others.

In applying carbon bisulfide emulsion to turf, the concentrated emulsion previously mentioned is diluted at the rate of 1 quart to 50 gallons of water. This is usually applied by means of a machine known as a proportioner. This machine is so constructed that it can be attached to the hydrant, and as the water flows through the hose the desired quantity of concentrated emulsion is added to the water stream, the amount added being regulated by a simple adjustment of a needle valve. The proportioner has been used successfully in the treatment of golf greens in New Jersey and Pennsylvania with carbon bisulfide. The dilute emulsion is applied to the turf at the rate of three pints to each square foot of sod, and is effective to a depth of 3 or 4 inches.

Several years of experiment work have shown that lead arsenate mixed with the surface layer of soil will control scarabaeid larvae and other soil inhabiting insects, and will not harmfully affect the growth of the grasses commonly used in golf greens and lawns. The grasses which have been found to grow successfully in soil poisoned with lead arsenate include the several varieties of bent, perennial rye grass, Chewing's fescue, meadow fescue, sweet vernal grass, and Kentucky blue grass. When a lawn is being made or a golf green prepared, lead arsenate may be mixed with the soil at the rate of 1,500 pounds to the acre. One application of this amount of lead arsenate has been found effective for about six years, during which time a lawn so prepared has been entirely free from infestation. It is possible to treat lawns already planted with a top dressing of 5 pounds of lead arsenate, mixed with the usual lawn fertilizer, to each 1,000 square feet. It has been found possible to maintain a much purer stand of grass on lawns which have been treated with lead arsenate, due to the fact that crab grass, chickweed, dandelion, and sour dock do not grow well in the treated soil.

Parasite Introduction.

Eight years of work has resulted in the establishment in New Jersey, New York, and Pennsylvania of five species of parasites from the Orient. The first of these to be established was a tachinid fly (*Centeter cinerea* Aldrich) which is parasitic on the adult Japanese beetle. It was first known to be established in this country in 1923, and since that time has spread outward from the central point of liberation over an area of approximately 90 square miles. Two dexiids, *Prosena siberita* Fabr. and *Dexia ventralis* Aldrich, parasitic on the larvae of the Japanese beetle, have been found to be established during the past year. Both species are effective as parasites of *Popillia* in Japan. *Dexia* has three generations a year in Japan, but, thus far, only two generations have developed in the United States. Two solitary wasps, *Tiphia popilliavora* Rohwer and *Tiphia vernalis* Rohwer have been introduced, and are now established in this country. *Tiphia popilliavora* was sufficiently numerous near Riverton, New Jersey, in 1927 to enable us to establish eleven sub-colonies of this parasite in New Jersey and Pennsylvania. Recoveries in 1928 indicate that eight of the eleven sub-colonies have been successfully established. At the present time two members of the Laboratory force are located in Japan and Korea, and one in Northern India, for the purpose of collecting and rearing parasites for shipment to this country.

Conclusion.

The Japanese beetle, introduced into the United States sometime prior to 1916, found favorable conditions for its rapid multiplication. Since it attacked most of the crops grown in the North-eastern States, it presented a serious problem to American agriculturists. As a result of research work, methods have been developed for the protection of most economic plants, and, through the introduction of foreign parasites and the increase of other factors of natural control, it is evident that the numerical increase of the species has been permanently checked in the district occupied for the longest time by the Japanese beetle. Each year is bringing forth improved and more economical methods of plant protection, and the outlock for the ultimate control of this insect by natural agencies is most hopeful.

Periodic Reversal of Heart-beat in Bombyx and Other Moths*.)

John H. Gerould, Dartmouth College, Hanover, N. H.

(With 3 text-figures.)

I think that you will agree with me that all text-books of entomology state that the heart or dorsal vessel in insects propels the blood by waves of peristalsis from behind forward. In case the heart is described as chambered, as in most-books, it is implied that valves between chambers prevent backward flow.

Four years ago, in October 1924, I accidentally found that the chrysalids of the common alfalfa butterfly, *Colias eurytheme,* show periodic reversal in the direction of the pulsation, that is, the heart intermittently reverses and beats backward. I had known of this phenomenon only in the Tunicates or Ascidians, degenerate relatives of the true Vertebrates, in which group this peculiar heart action has often been described as unique.

A brief note was then published in Science on "Periodic reversal of heart-beat in a chrysalis", in preparing which I found that the text-books of Berlese and Henneguy call attention to a paper by Bataillon (1893) in which he described periodic reversal in the silk-worm chrysalis. A few months after this note appeared in Science, I was in Paris and there I looked up the history of the discovery of periodic reversal in the silk-worm. In brief, I learned that Malpighi in 1669 found that the heart-beat in the vivisected silk-worm *moth* is as likely to be directed backward as forward and is extremely variable. Réaumur (1734) claimed that in the moth the blood flows always backward. Cornalia (1856) confirmed Malpighi's observations by studies on the pupa, but made no observations on the imago. He regarded the continuance of the phenomenon into adult life as probable, though difficult to observe on account of a supposed opacity of the skin. Bataillon (1893) described periodic reversal in the mature larva and in the pupa as a temporary eccentricity connected with metamorphosis and due to asphyxiation, and he claimed that in the moth the "normal action" of forwards beating was restored. Dr. E. Fischer of Zürich (1918) saw periodic reversal in the fresh chrysalids of diurnal butterflies several years before I did. He doubted whether "antiperistalsis" was really backward flow, and in his published note he gave no information about the adult.

---

*) A more extensive and detailed paper on this subject is nearly ready for publication. Grateful acknowledgement is made for financial assistance rendered by the Joseph Henry Fund.

The next step was to breed silkworms to find out who was right about the moth, Malpighi or Bataillon. Last summer I found that by the simple expedient of scraping the hair-like scales off the back of a moth, periodic reversal can be seen in the adult without vivisection and that vivisection also amply confirms that which can be seen in the uninjured, somewhat dilapidated, insect.

In brief, periodic reversal is not a transitory phenomenon as Bataillon believed, but is characteristic of the pupal and adult stages of probably all Lepidoptera. I have studied it in some detail in *Telea polyphemus*, seen it in *Actias luna*, *Samia cynthia*, in a hawkmoth *(Sphinx chersis)*, in *Ctenucha virginica*, the wingless female of *Notolophus leucostigma*, *Argynnis aphrodite*, etc.

If one cuts open the cocoon of a silk-worm and extracts the chrysalis within twenty-four hours after spinning, the pulsation is wholly forward, but at about twenty-four hours after the cocoon is spun and forty-eight hours before pupation, or the stripping off of the larval skin, backward peristalsis begins.

Description of Periodic Reversal.

After beating forward a variable number of times, the dorsal vessel beats backward a somewhat similar number. The average number of beats in one forward or backward phase in the mature larva (prepupa) is slightly over 100, a few more beats forward than backward (123 vs. 104) (text-fig. 1). Each forward phase lasts 3—4 minutes, the backward is twice as long (text-fig. 2). The average length of one beat is about 1.8'' forward, 3.5'' backward at room temperature, 20° C *).

The rate forward is about twice as rapid as that backward (text-fig. 3). The rate at the beginning of a forward phase is more rapid and diminishes gradually, as a rule, during the course of the phase. The final forward beats are either met by the first backward of the succeeding phase, or a pause may ensue before the slower backward beating of the next phase is established.

The backward phase occurring in certain individuals during pupation may be called "double action", backward from the junction of the 3rd and 4th abdominal segments and simultaneously forward through the first three abdominal segments and the aorta. In other words, the waves diverge. Reversal under these conditions does not take place in the aorta, and the backward stream in the heart is supplied from the ventral sinus at this point. During the first few hours after pupation the backward phases in all six individuals of which a record was kept exhibited only double action, but early in pupal life **) this sort of backward peristalsis gives way to complete reversal throughout the whole dorsal vessel, which is characteristic also of the adult.

---

*) The rate, or time elapsing between successive beats, depends so largely on temperature that the observations recorded in this paper were made at a temperature as nearly constant as possible, viz. 20°—21° C (68°—70° F).

**) Before 14 hours in one case.

The chrysalis of *Colias eurytheme* as stated in my earlier paper (G e r o u l d, 1924) regularly combines both types of peristalsis in a single backward phase, that is, approximately the first 12 beats of each backward phase involve double action, the others involving complete antiperistalsis throughout the whole dorsal vessel.

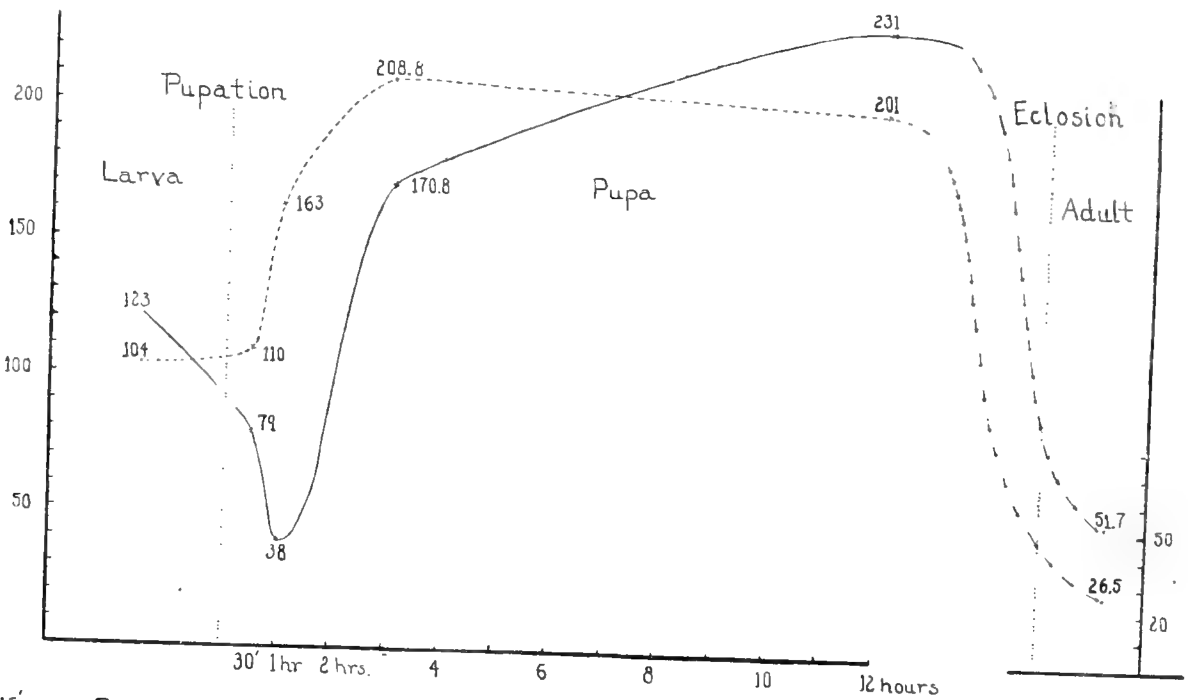


Fig. 1.

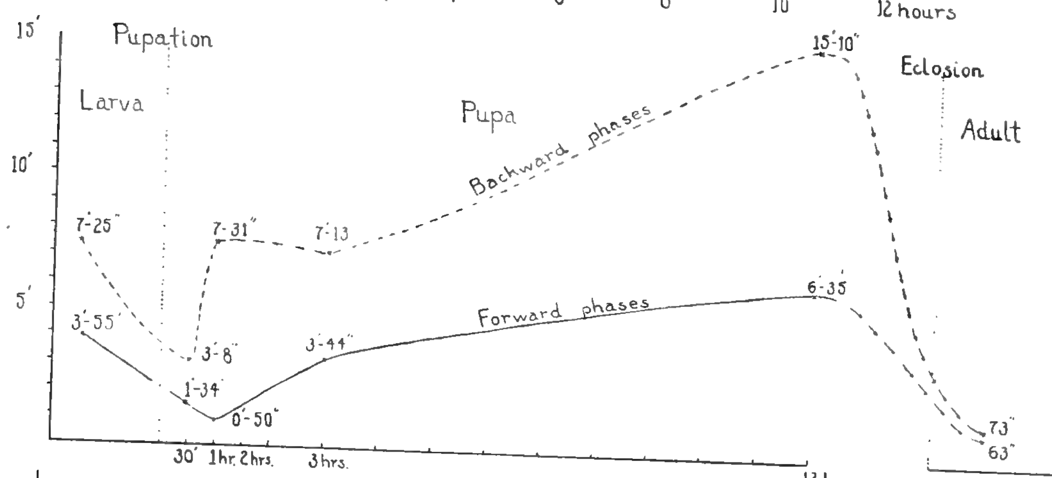


Fig. 2.

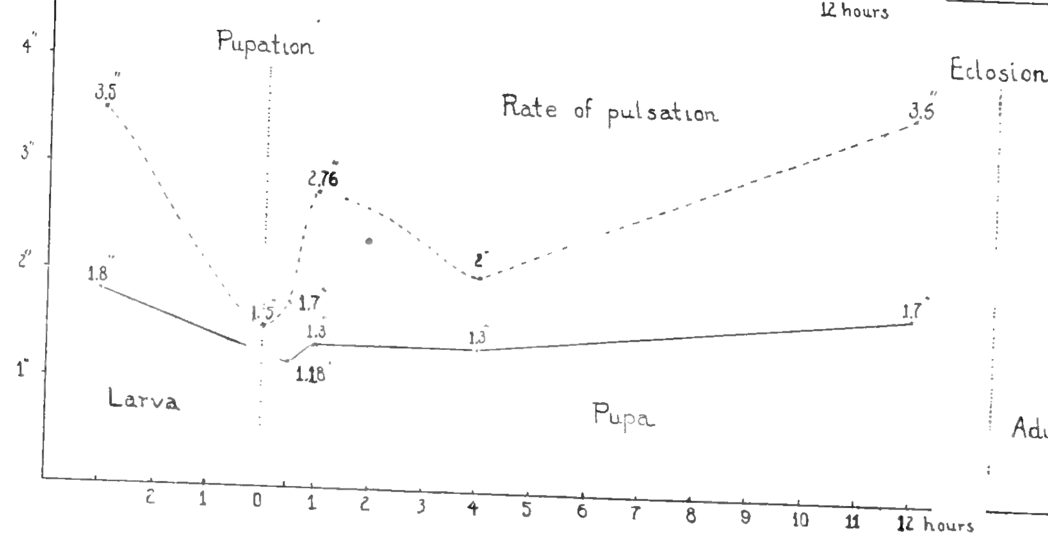


Fig. 3.

P u p a t i o n. — During these few minutes peristalsis is always inverse, that is, either wholly backward or both ways at once, double action. Circulation is intensely active; the backward beating of the distended heart, filling the abdomen full, stretches the larval skin and assists in sloughing it off. In a certain individual approaching pupation, the average rate of forward beating in successive phases became retarded, that of the slower backward beating accelerated, until there was little difference between them (table 1).

Table 1.

Periodic reversal of heart-beat in a larva just before pupation.
Temperature 74^0 F = 23^0 C.

Forward				Backward				
Beats	Time ′ ″	Seconds	Av. Rate 1 beat ″	Beats	Time ′ ″	Seconds	Rate	(1 beat in seconds)
				→ 55	2—36	156	2.8	
→ 34	1—0	60	1.7	57	2—24	144	2.5	
→ 35	1—0	60	1.7	65	3—0	180	2.7	
→ 35	1—12	72	2.0	64	2 36	156	2.4	
→ 34	1—12	72	2.2	60	2—24	144	2.4	
→ 31	1—12	72	2 3	1661	57—0	3420	2.0	
			Rate retarded		Count broken off at 57 minutes This phase continued through pupation (observed 1 hour 33 min.)		Rate accelerated	

(It should be mentioned that the alternating phases are rarely as even in length as in this record. The observation begins with a backward phase of 55 beats, followed by a forward of 34, backward of 57, etc.)

During a single extraordinarily long backward phase (double action) which included the few minutes of actual pupation, the rate in this individual was also very gradually accelerated from 1 beat in 2.4½″ at first to 1 beat in 1.3″ during actual pupation, reaching 1 per second just before bursting of the skin (table 2). When pressure was momentarily relieved by the uncovering of the thorax, the rate was retarded for an instant. Since this whole backward phase was over one hour and a half long, the details of the changes of rate could be observed very advantageously.

P u p a. — The most distinctive change which takes place in pupal life is the rapid increase in the length of both forward and, especially, backward phases. After 12 hours, the average length of the backward phases is over 15 minutes, of the forward 6½ minutes (text-fig. 2). Thus, the backward phases are on the average twice as long as the forward, just as before pupation. Both are about double the lengths observed in the mature larva.

The number of beats in a phase is necessarily greatly increased now that the phases have lengthened, but since the average rate of forward beating changes very little, while that of backward beating diminishes considerably after the excitement of pupation is over, the average number of backward beats becomes less than that of the forward (text-fig. 2). This is true both of the larva and of the moth, that is, at all times except around pupation, when inverse beating is predominant.

The long phases reveal clearly the gradual retardation in rate which regularly occurs during a single phase, whether forward or backward. To mention a single example, the following measurements of 10 beats in seconds were recorded from a pupa of 8½ days during a backward phase of 8½ minutes: 27″, 27½, 28, 28½, 28½, 29, 30, 30, 30, 31, 31⅕, 31⅕, 36″, giving an average of 3.0″ with a range from 2.7″ to 3.6″. Samples

of the following forward phase gave the series: 15″, 19, 19, $19\frac{1}{5}$, $20\frac{2}{5}$, $22\frac{1}{2}$, 22, 22, 22, with an average of 2.0″. In view of this variability, it is surprizing that the averages are so regular, especially in forward beating.

Table 2.

Pulse rates (seconds per 10 beats) during an extraordinarily long backward phase (double action) before, during and after pupation. Temperature 74° = 23° C. The first part (11: 24 a. m.—12: 21 p. m.) covers the last partial phase given in table 1. The latter part continues this phase, including samples of 10 beats taken up to, during, and after pupation. Note the gradual acceleration form 10 beats in $24\frac{1}{2}$″ at first, to 10 beats in 10″ after pupation has begun. No reversal to beat forward occurred for over an hour and a half.

11 : 24 a. m.										
$24\frac{1}{2}''$	$23''$	$23\frac{1}{2}''$	$22''$	$22''$	$22\frac{1}{2}''$	23	$22\frac{1}{2}$	$22\frac{1}{2}$	23	22
23	24	$22\frac{1}{2}$	$22\frac{1}{2}$	22	$22\frac{1}{2}$	22	$21\frac{4}{5}$	$21\frac{4}{5}$	$21\frac{1}{2}$	21
								11 : $47\frac{1}{2}$ a. m.		
21	$21\frac{4}{5}$	$21\frac{1}{5}$	$21\frac{4}{5}$	22	21	21	$21\frac{1}{2}$	21	$21\frac{1}{5}$	21
								11 : 55	11 : 57 a. m.	
21	$20\frac{4}{5}$	21	21	21	$21\frac{1}{5}$	$20\frac{1}{5}$	21	20	$21\frac{1}{2}$	$22\frac{1}{2}$
21	20	$20\frac{1}{2}$	$20\frac{1}{2}$	20	20	21	20	22	$21\frac{1}{2}$	20
$21\frac{4}{5}$	20	19	20	20	$19\frac{4}{5}$	20	19	18	20	19
19	19	18	19	19	19	$19\frac{1}{2}$	$17\frac{1}{2}$	19	$17\frac{1}{2}$	18
				12 : 20 p. m.					12 : 25 p. m.	
$17\frac{3}{5}$	18	18	$17\frac{1}{2}$	$17\frac{1}{2}$	17	(1661 beats in 57 min)			16	$15\frac{3}{5}$
15	15	$14\frac{1}{2}$	15	14	$13\frac{4}{5}$	14	14	14	14	$13\frac{1}{2}$
		12 : 31 p. m.							12 : $34\frac{1}{2}$ p. m.	
$14\frac{1}{2}$	14	14	14	13	14	$13\frac{4}{5}$	$13\frac{1}{2}$	$14\frac{1}{2}$	14	14
						12 : 38				
14	14	14	$13\frac{4}{5}$	14	14	$13\frac{4}{5}$	14	$13\frac{4}{5}$		
Shedding begins (tail)										
14	14	14	10	11	11	$13\frac{3}{4}$				
Skin bursting Thorax exposed										
		12 : 47						12 : 51	Skin almost off	
$14\frac{1}{2}$	14	$14\frac{1}{2}$	$16\frac{1}{2}$	17	$15\frac{1}{2}$	15	$13\frac{1}{2}$	13	13	$13\frac{1}{2}$
$13\frac{1}{2}$	13	14	12 : 53 p. m. End of pupation.							
	12 : 54			12 : 57 p. m., end of observation,						
Pupa	$13\frac{4}{5}$	$14\frac{1}{2}$	15	$13\frac{1}{2}$ Backward beating still continues (pronounced "double action").						

One of the most amazing peculiarities of some pupae several days old are the long pauses between successive phases. These come at the end of forward phases. In one pupa, $3\frac{1}{2}$ days old, a pause of 1 hour 24 minutes occurred at noon and one of 1 hour 17 minutes when I returned in the afternoon. The latter was interpolated between a forward phase of $9\frac{1}{2}$ minutes and a backward of $10\frac{1}{2}$.

A d u l t. — Periodic reversal of peristalsis in the whole dorsal vessel occurs in the adult *Bombyx mori*, as contrasted with fresh pupae, which, in backward phases, show double action.

The average rate of pulsation in the adult changes very little from that in the mature pupa. The average rate backward was then $3\frac{1}{2}$″ per beat *) and is now slightly faster (2.9″); the rate forward is as in the earlier stages 1.7″ (fig. 3), but the length of phase has noticeably shortened to about one minute, the forward phases exceeding the backward (fig. 2).

Great individual variations have appeared in the length of the alternating phases and number of beats in a phase, and the male is remarkable

*) Recent studies of older pupae (10 days after pupation) show a rate exactly like that here recorded for the adult, 1 beat in 2.9″.

in this respect. A certain male showed a tendency to long forward phases, on one occasion over a half hour (32½') with 1280 beats; the next day he was normal; the third day he exhibited a forward phase of 19½ minutes. Another male showed a similar tendency to long backward phases.

The female, with few exceptions, is much more stable in the balance of her alternating phases. Her circulation is not as much affected by mating as is that of the male. In general, mating in both sexes tends to increase the length of phase and number of beats in a phase. Mating in the male accelerated backward, retarded forward peristalsis. Possibly the opposite is true of the female, but the data on that point are not conclusive.

Old age abruptly diminishes the length of phase and number of beats in a phase. Reduction of phases to single beats then often occurs, so that Malpighi's comparison of periodic reversal to the tossing of a ball back and forth between two players is now particularly appropriate.

Nature of the heart, and what happens in inverse peristalsis.

The excellent studies of Verson (1908) were correct in showing that the silkworm heart is a simple tube without chambers. The exceedingly minute lateral ostia are shaped somewhat like the gill-slits of a shark, bottomless pockets extending forward through the wall of the heart. They can no more impede the flow of blood backward than the abutments of a bridge can impede the flow of a river. In backward beating, those at the posterior end of the heart simply open and let the blood out into the sinuses (cf. Verson's illustrations, l. c. Tav. 2, fig. 18, 29).

Functional importance. — It seems obvious that impulsion of the blood stream backward is useful in irrigation and nourishment of the ovaries. The rapid increase in size of these organs during the metamorphosis is accompanied in the higher insects by constriction of the abdomen, which occurs in the prepupa just at the onset of periodic reversal. If the constricted waist acts as a dam or valve impeding somewhat backward flow of haemolymph in the ventral sinus between thorax and abdomen, a more vigorous irrigation of the voluminous ovaries would occur in backward beating than that supplied from the thorax by the gentle backward flow in the ventral sinus. Backward peristalsis, accordingly, probably serves this important function in Lepidoptera. During backward phases, ostia at posterior end of the heart stand open, and the blood flows out into the sinuses around the ovaries.

Theory of the cause of periodic reversal.

In my earlier paper, Gerould (1924), I held that backward peristalsis is induced by back-pressure of haemolymph in head and thorax due to the probable action of the constricted waist as a valve controlling lacunar circulation. The fact that the first appearance of backward peristalsis coincides with the profound change of form (constricted waist) of the caterpillar as it becomes a prepupa suggested this explanation.

An important objection to this theory is that periodic reversal continues when the dorsal wall of the abdomen with dorsal vessel attached

to it is cut out of the body. If such a preparation is enclosed in a moist chamber, periodic reversal continues for 24 hours, or as long as peristalsis occurs. Back pressure, therefore, does not appear to be necessary to induce reversal. The backward-forward alternation of single beats seen in old moths likewise is inconsistant with the backpressure hypothesis.

The studies of Carlson (1906) and others have shown that the heart beat in Arthropods is of nervous origin and that rhythmic peristalsis is due to chemical changes in a ganglion where the wave originates. Such ganglia may be expected, therefore, at the anterior end of the aorta as well as at the posterior end of the dorsal vessel, of the adult moth. "Double action", or diverging peristalsis, suggests that in the mature larva (prepupa) an additional source of peristalsis occurs between the 3rd and 4th abdominal segments. In the middle of the 4th segment of a large mature hawkmoth larva just in front of the muscular alae, I have seen on the dorsal wall of heart a pair of transparent refractive bodies which may be such ganglia, though precise neurological studies have not yet been made and the nervous control of the heart in the silkworm requires further investigation.

Conclusion.

It is the purpose of the present paper to bring out the fact, hitherto unnoticed, that periodic reversal of heart action occurs in Lepidoptera generally, not merely in the prepupa and pupa, as Bataillon and Fischer found, but also throughout adult life.

We are this year celebrating the 300th anniversary of the publication of Harvey's epoch-making De motu cordis. In 1628, also, Marcello Malpighi war born, who extended Harvey's work by discovering circulation through the capillaries. To him we owe the first description of periodic reversal of heart-beat in the silkworm moth, a description vivid and substantially correct, though his conception of the dorsal vessel in the moth as a series of chambers or little hearts (corcula) was erroneous. It is astonishing that this interesting phenomenon, so readily observed in any large moth or butterfly, has for three centuries almost escaped notice. Seldom, if ever, has a discovery remained so long in oblivion.

Literature.

1. Bataillon, E. — 1893. La métamorphose du ver à soie et le déterminisme évolutif; in Bull. Sci. France et Belgique, 25, p. 18—55.
2. Carlson, A. J. — 1906. Comparative physiology of the invertebrate heart. — IV. The physiology of the cardiac nerves in the Arthropods; in American Journ. Physiol. 15, p. 127—135.
3. Cornalia, E. — 1856. Monographia del Bombyce del Gelso; in Mem. dell'I. R. Inst. Lombardo, Milano, 6, pp. 388, 15 pl.
4. Fischer, E. — 1918. Eine bei Raupen und Puppen beobachtete Umkehrung der peristaltischen Herzbewegung; in Entom. Rundschau, Stuttgart, 35, p. 9—10.
5. Gerould, J. H. — 1924. Periodic reversal of heart-beat in a chrysalis; in Science 60, p. 570—572.
6. Malpighi, M. — 1669. Dissertatio epistolica de bombyce. London.
7. Réaumur, R. A. F. de. — 1734. Mémoires pour servir à l'histoire des insectes, 1, p. 643, Paris, 1734—1742.
8. Verson, E. — 1908. Sul vaso pulsante della sericaria; in Atti del reale Inst. Veneto di sci., lett. ed arti 67, p. 1391—1291, 2 pls.

A Qantitative Method of Estimating the Relative Toxicity of Stomach-poison Insecticides.

F. L. Campbell, Associate Entomologist, and R. S. Filmer, Junior Entomologist, Deciduous Fruit Insect Investigations, Bureau of Entomology, U. S. Department of Agriculture, Washington, D. C.

(With one text-figure and Plate IV.)

The arsenical residue situation has not only stimulated the search for new stomach-poisons but has emphasized the desirability of comparing their toxicity for mammals and insects. A stomach-poison, ideal in this respect, would be highly toxic to insects and non-toxic to mammals. There is no reason to believe that such a compound exists, but some substances should be more specifically toxic for insects than others. Pyrethrum, for example, has always been thought to have a high factor of safety for mammals. A measure of this factor of safety remains to be devised. A suitable method having been found, it should first be applied to determine the factor of safety, if any, of our present stomach-poisons, so that new compounds, markedly safer for mammals, can later be recognized and developed.

The acute toxicity *) of poisons for mammals is always expressed in terms of the least weight of a compound which will kill a unit weight of animal. That particular dose is usually called the minimum lethal dose (M.L.D.). A more exact definition of M.L.D. has recently come into general use; i. e., a dose which will kill 50% of a group of similar animals on a unit weight of animal basis.

Minimum lethal doses of a series of compounds for the same species of animal express in a logical and quantitative way their relative toxicity for that species. So also do minimum lethal doses of the same compound for different species express the relative susceptibility of the animals to that compound. Therefore, in order to measure the relative susceptibility of an insect and a mammal to any stomach-poison, it is necessary to determine the respective minimum lethal doses by mouth. The factor of safety will be the ratio of the M.L.D. for the mammal to that for the insect.

So far as the writers know, no trustworthy data have been published on the M.L.D. of any commercial stomach-poison for any insect, **) but a

---

*) By acute toxicity we mean the effects following the administration of a single dose in distinction to chronic effects following the administration of a number of sublethal doses over a period of time.

**) The U. S. Chemical Warfare Service and the Russian Laboratory for the Study of Poison Substances have recently attemped to determine the M.L.D. of arsenicals by analysis of poisoned insects for arsenic. Although the analytical method might conceivably lead to accurate and reproducible results, it is beset by many difficulties which the laboratories just mentioned have not yet overcome.

few figures on the M.L.D. of common stomach-poison insecticides for certain laboratory mammals are to be found in the literature. The problem, therefore, is to devise a method for determining the M.L.D. of relatively insoluble stomach-poisons for insects or, in other words, to feed known doses of these poisons in any desired amount to individual insects.

The purpose of this paper is to describe such a method for the silkworm, to present the minimum lethal doses of certain well-known stomach-poisons for this insect, and to compare some of them with results already obtained by other workers on rabbits.

Since this paper deals only with acute poisoning, no speculations or conclusions as to the bearing of these results on questions of public health are permissible. A comparative knowledge of acute toxicity of stomach-poisons for insects and mammals merely promises to point out those compounds whose chronic effects would be worth studying.

Method.

The method may best be described by outlining the course of the work required to determine the relative toxicity of aluminium arsenate and acid lead arsenate. Only two compounds at a time were compared, one of which was always acid lead arsenate to serve as a standard of reference.

Forty fourth instar silkworms (mean weight about 0.30 grams) were weighed individually to a decigram on a chainomatic balance and were placed without food in 40 marked Petri dishes, one larva to a dish. Each dish was covered by a dish of the same diameter to provide a deeper container than the ordinary Petri dish with overlapping lid. The insects were allowed to become hungry for an hour or two while the poisoned food was prepared.

Two 2.22 cm. (7/8 in.) circular cover glasses were weighed on a microbalance to 0.01 mg. Eighty disks of this diameter vere stamped out of selected thin flat mulberry leaves by a tool steel cutter shaped like a cork borer. The cover glasses were placed in the center of a 24 cm. square glass plate and 40 leaf disks were arranged closely around them, smooth surface up, as shown in Plate IV, A.

A simple dusting apparatus, shown in text-fig. 1, was charged with 1 or 2 grams of acid lead arsenate. The powder was placed in the bulb of a shortened 50 cc. pipette, the lower entrance to which was closed by a paraffin ball. The upper end was forced into a perforated cork stopper, the top of which lay flush with the floor of the dusting stand. The lower end was attached by rubber tubing to a compressed air line. A battery jar, 22 cm. diam. and 30 cm. high, to be filled with dust was inverted over the cork stopper. A stand similar to the dusting stand was placed by its side. When the air was turned on, the powder whirled about in the pipette bulb, where lumps were broken up, and a fine stream of dust was ejected from two small holes in the cork stopper, filling the jar with a dense dust cloud. While the larger particles were falling to the floor of the stand, the plate bearing the leaf disks was placed on the stand next to the dusting apparatus. The jar was then lifted a few millimeters and was moved across to a position above the glass plate where it was lowered quickly upon the plate. The dust cloud settling slowly upon the plate, leaves, and

cover glasses, covered them with a remarkably fine and uniform deposit, the amount of which depended on the time the jar was allowed to remain on the plate.

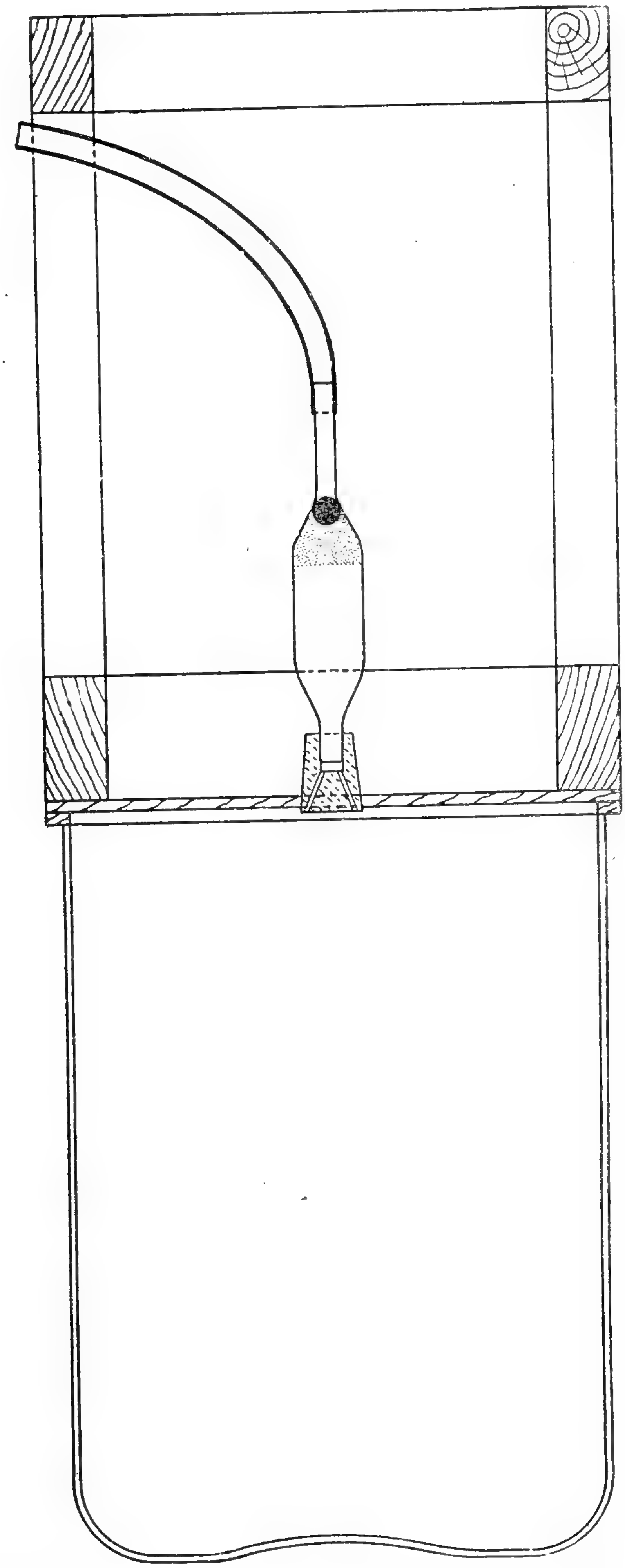


Figure 1. — Section through dusting apparatus for depositing a uniform layer of dust on a surface 22 cm. in diameter.

The cover glasses were weighed again, increase in weight divided by 2 giving the quantity of acid lead arsenate per leaf disk. About 0.20 mg./disk or 0.05 mg./sq. cm. was a satisfactory coating.

A sandwich was then prepared from each disk in the following manner: A poisoned leaf disk was transferred by forceps to a clean glass plate. The smooth surface of a similar unpoisoned disk was coated by a camel's hair brush with a film of corn starch paste, made fresh every day. With forceps the disk was grasped by a vein on the other surface and carefully lowered upon the poisoned disk. The two disk were then pressed together by a cork thus completing the sandwich. An edge of each sandwich was inserted into a split half cork stopper so that it would be held firm in a position suitable for a silkworm to feed on it. A sandwich in its cork was then placed in each Petri dish with a silkworm.

Within 5 minutes most of the larvae began to eat along the margin of the sandwich as if it were a single leaf. Individual dosages were varied at will by taking the sandwiches from the larvae after they had eaten from $^1/_8$ to $^1/_2$ of them. Usually about 90% of the larvae consumed a satisfactory dose in 10 to 20 minutes. The remainder served as controls. Each worm was given a fresh mulberry leaf and the 40 dishes were placed in an air bath at 27.2 ± 0.1^0 C to await death or recovery of the larvae.

The partially consumed sandwiches were arranged in order on a 10 cm. by 13 cm. glass plate, 20 to a plate, and the necessary identification was printed on the plate in india ink. It was covered by a similar glass plate and the two were bound together along the margins by lantern slide binding. A finished preparation is shown in Plate IV, B. The plates were set aside in a moist chamber where they might be allowed to remain as long as a week before enlarging them. It was neither practicable nor necessary to enlarge them immediately.

The foregoing procedure was repeated for 40 more insects with aluminium arsenate, completing the day's work. Because of its lower toxicity aluminum arsenate had to be dusted twice on the leaf disks to obtain a sufficiently heavy deposit.

The next morning the dead insects were recorded. The living insects were given fresh food and returned to the air bath for 24 hours. Preliminary experiments showed that if a larva was alive and feeding at the end of two days, it was almost certain to complete its development. Such larvae were said to have recovered; the others died. Most of the larvae that were going to die, however, succumbed during the first 24 hours.

Every week the sandwich plates, like photographic negatives, were printed with enlargement to 28 cm. by 35.5 cm. providing permanent records of the dose taken by each larva. Since sandwiches in the plate shrink unequally during storage, those at the corners shrinking most, it was necessary to estimate what the area of each enlargement would have been if none of the sandwiches had been eaten. This was done by fitting cardboard disks of known area to the remaining circular margins of the enlargements. Then the actual area of each enlargement was measured by polar planimeter. The area eaten was obtained by difference. The dose in mg. of poison per gram of insect consumed by each silkworm was calculated by slide rule to 1 or 2 significant figures.

If it chanced that suitable doses were fed, it was found that above a certain dose all worms died, between that dose and a lower one some died and some recovered, and below the latter dose all worms recovered. The

first mentioned dosage range may be called the lethal zone, the second the intermediate zone, and the third the sublethal zone. We are particularly interested in the intermediate zone, the median dose of which is the M.L.D. from which 50% should die and 50% recover.

The first day's comparison of the toxicity of a stomach-poison with that of acid lead arsenate usually did not provide enough cases in the intermediate zone for delimitation of the M.L.D. A second comparison guided by the results of the first was often sufficient to delimit the M.L.D. satisfactorily.

As an example, a complete list of doses fed to determine the relative toxicity of acid lead arsenate and aluminium arsenate is presented in Table 1. The results are arranged in numerical order and separated into the three zones. The intermediate zone for acid lead arsenate lies between 0.10 and 0.08 mg./gram; that for aluminium arsenate lies between 1.1 and 0.8 mg./gram. Since the pharmacologist can rarely afford to use so many mammals for delimiting an M.L.D., we believe we have used more than a sufficient number of individuals to obtain results suitable for comparison with mammalian data, although our numbers in the intermediate zone are still insufficient for statistical treatment. We choose as the M.L.D. that dose in the intermediate zone which appears by inspection to be the median. So we call 0.09 mg./gram the M.L.D. for acid lead arsenate and 0.9 mg./gram the M.L.D. for aluminum arsenate.

Table 1. — Relative toxicity of acid lead arsenate and aluminum arsenate. Individual doses in mg. of poison per gram of fourth instar silkworm.

	Lethal zone					Intermediate zone		Sublethal zone			
	Died					Died	Recovered	Recovered			
Acid lead arsenate	0.53	0.22	0.18	0.14	0.12	0.10	0.10	0.07			
	0.48	0.21	0.18	0.14	0.12	0.10	0.10	0.07			
	0.48	0.21	0.18	0.14	0.11	0.10	0.10	0.07			
	0.43	0.20	0.17	0.13	0.11	0.10	0.09	0.07			
	0.41	0.20	0.16	0.13	0.11	0.10	0.08	0.06			
	0.34	0.20	0.16	0.13	0.11	0.09	0.08	0.06			
	0.34	0.19	0.15	0.13	0.11	0.08		0.05			
	0.23	0.19	0.14	0.13	0.11			0.03			
	0.23	0.19	0.14	0.13	0.11						
	0.23	0.19	0.14	0.12							
Aluminium arsenate		3.1	1.6	1.4	1.2	1.1	1.1	0.7	0.6	0.5	0.4
		2.3	1.5	1.4	1.2	1.1	1.0	0.7	0.6	0.5	0.4
		2.2	1.5	1.3	1.2	1.1	0.9	0.7	0.6	0.5	0.4
		1.9	1.5	1.3		1.1	0.9	0.7	0.6	0.5	0.4
		1.8	1.5	1.3		1.0	0.9	0.7	0.6	0.5	0.4
		1.6	1.5	1.3		1.0	0.8	0.7	0.6	0.5	0.3
		1.6	1.4	1.2		1.0	0.8	0.6	0.5	0.5	0.3
		1.6	1.4	1.2		0.9	0.8	0.6	0.5	0.5	0.3
		1.6	1.4	1.2		0.9		0.6	0.5	0.5	0.1
		1.6	1.4	1.2		0.8		0.6	0.5	0.4	

Discussion of Method.

In 1926 Janisch (6) estimated the relative toxicity of certain stomach-poison insecticides in the following manner: He measured the area of each piece of cabbage leaf on cross-section paper, dusted the leaf by shaking it with the poison in a flask, weighed it again, and placed it with a single cabbage worm which fed on it until death. He measured the remaining leaf area and calculated the dose on the assumption that the dust was distributed evenly on the leaf surface. Neither discussion of errors nor units of measurement were given.

We have improved Janisch's method, making it more rapid and accurate. Our dusting method enables us to prepare 40 known doses with one weighing and to weigh glass instead of leaf, thus eliminating the serious error of water loss from the leaf during weighing. The uniformity of our dust deposit was tested by allowing it to fall on weighed cover glasses placed on different parts of the plate. The variation was within the error of weighing; i. e., the weights agreed to 0.01 mg. The appearance of a satisfactory acid lead arsenate deposit (0.031 mg./sq. cm. in this case) is shown in Plate IV, C.

Janisch used a single leaf on which the dust was exposed to contact with the body of the larva, which, on crawling over the dust, would have certainly picked up an unknown part of it on the legs or brushed it off the leaf. Enclosed in our sandwich, however, the dust cannot be disturbed, and when both leaves are eaten simultaneously, as is done by the silkworm, the poison in between must of necessity be completely consumed. Extremely heavy deposits of relatively non-toxic compounds may be tested in this way. The two parts of each piece bitten out of the sandwich separate in the alimentary tract as shown by microscopic examination of the intestinal contents of poisoned larvae. So the poison is just as available for the action of the stomach juices as if it had been exposed on a single leaf.

It could be objected that the uniformity of the deposit might be disturbed in making the sandwich. If this error occurs, it is not great enough tho affect the results seriously. Indeed, the best answer to adverse criticism of the sandwich method is the reproducible M.L.D. for acid lead arsenate. In comparisons with 7 other compounds its M.L.D. varied between 0.10 and 0.08 mg./gram. The tests were made from time to time during two months and involved the feeding of known doses of acid lead arsenate to 385 fourth instar silkworms. Fourth instar larvae were always used rather than full grown worms not only because of food and space economy and greater freedom from disease, but because the younger worms have more time in which to effect complete recovery from a sublethal dose before pupation.

The chief defect of this and of any leaf area method is that doses cannot be accurately predetermined. Time and insects are wasted in feeding lethal or sublethal doses which do not help to delimit the M.L.D. It would be desirable to force a predetermined dose directly into the alimentary tract of an insect. This can be done with solutions, Campbell (1), but has not yet been accomplished with suspensions.

Whatever method is employed for determining the relative toxicity of stomach-poisons, the writers believe that it must provide for quantitative estimation of the individual or mean dose. The fundamental conception of toxicity is based on the weight of a compound required to kill, and even if a time or percentage-kill basis of comparisons is adopted, it is necessary to administer equal weights of compounds. Most stomach-poison tests, however, have been made by spraying or dusting unknown amounts of poison on foliage and comparing the percentage of insects dead after eating unknown amounts of poison during an arbitrary period of time. This procedure answers the question as to which of two or more compounds applied at the same concentration will kill a given number of insects most quickly with least damage to the foliage; in other words it measures relative effectiveness. It may measure relative toxicity also, if, by chance, equal mean lethal doses were consumed. But since the doses taken are unknown and are not likely to be equal, the results mean very little in terms of relative toxicity, though decided differences in toxicity have been and can be detected in this way.

The terms effectiveness and toxicity should be differentiated and used more carefully in the future. Toxicity of a stomach-poison refers to its inherent killing power as it lies in the alimentary tract. Effectiveness embraces toxicity and other factors which influence rate of fatality when a stomach-poison is consumed *ad libitum* by an insect. Among these factors are concentration of the poison on foliage and repellency or attractiveness of the poison. But toxicity is probably the most important single factor in effectiveness.

Results.

Analyses of the compounds tested are given in Table 2. With the exception of acid lead arsenate and sodium fluosilicate, their composition and purity are questionable. For the sake of obtaining results of universal and permanent value, it would have been better to have used the purest compounds obtainable. But we felt constrained to use samples of the commercial compounds which are being tested at field stations against codling moth, in order to furnish information on their relative toxicity for interpretation of field results.

The data of seven comparative tests are summarized in Table 3. The numbers of insects which died or recovered in the lethal, intermediate and sublethal zones are given as well as the corresponding dosage ranges. The compounds are arranged in the order of their toxicity as indicated by the dosage ranges in the intermediate zone.

Since the intermediate dosage ranges of acid lead arsenate are about the same for each comparison, a mean value of 0.09 mg./gram was adopted as the general M.L.D. of our sample of this compound. The data were then condensed still further in the form of a relative toxicity table with acid lead arsenate as the standard equal to 1 (Table 4).

Table 2. Analyses of compounds used on this investigation *).

Copper cyanide 74.01% CuO. Some cupric copper is present.

Acid lead arsenate 65.46% PbO; 30.56% As_2O_5.

*) Furnished by Mr. C. M. Smith of the Food, Drug and Insecticide Administration and Dr. R. C. Roark of the Bureau of Chemistry and Soils.

Sodium fluosilicate 99.5% Na_2SiF_6.
Barium fluosilicate 65.4% $BaSiF_6$; 7.5% BaF_2HF.
Potassium fluosilicate 90% K_2SiF_6; 2% Na_2SiF_6; 2.7% KHF_2.
Cryolite 79.8% 3 NaF, AlF_3.
Basic lead arsenate 74.5% PbO; 23.2% As_2O_5.
Aluminium arsenate 35.80 % As_2O_5.

Table 3. Summary of data obtained in comparing separately the toxicity of seven stomach-poisons with that of acid lead arsenate. Dosages in mg./gram of fourth instar silkworm.

	Lethal zone		Intermediate zone			Sublethal zone	
	No. of larvae died	Dosage range	No. of larvae died	No. of larvae recovered	Dosage range	No. of larvae recovered	Dosage range
Acid lead arsenate	27	0.29—0.10	1	1	0.09—0.09	7	0.08 – 0.04
Copper cyanide	29	0.39—0.06	8	6	0.05—0.03	8	0.02—0.01
Acid lead arsenate	49	0.29—0.11	3	3	0.10—0.09	16	0.08—0.04
Sodium fluosilicate	34	0.36—0.11	7	7	0.10—0.07	18	0.06—0.02
Acid lead arsenate	33	0.32—0.11	5	13	0.10—0.07	21	0.06—0.02
Barium fluosilicate	122	0.97—0.16	14	18	0.15 0.09	20	0.08 0.02
Acid lead arsenate	32	0.38—0.11	5	6	0.10—0.09	32	0.08 – 0.02
Potassium fluosilicate	26	1.44—0.20	8	12	0.19 – 0.14	36	0.13—0.02
Acid lead arsenate	25	0.22—0.09	4	5	0.08 – 0.08	19	0.07 – 0.02
Cryolite	49	1.20—0.26	3	8	0.22—0.16	42	0.15 – 0.04
Acid lead arsenate	24	0.21—0.12	5	2	0.11 – 0.08	8	0.07—0.03
Basic lead arsenate	—	—	5	10	1.1 —0.9	38	0.8 – 0.1
Acid lead arsenate	49	0.53—0.11	7	6	0.10 – 0.08	8	0.07—0.03
Aluminum arsenate	33	3.1 —1.2	10	8	1.1 —0.8	39	0.7 —0.1

Table 4. Toxicity of certain inorganic stomach-poisons relative to acid lead arsenate as the standard equal to 1. Based on the M. L. D. in mg./gram of fourth instar silkworm.

	M. L. D.	Relative toxicity
Copper cyanide	0.04	2.2
Acid lead arsenate	0.09	1.0
Sodium fluosilicate	0.09	1.0
Barium fluosilicate	0.13	0.7
Potassium fluosilicate	0.17	0.5
Cryolite	0.18	0.5
Basic lead arsenate	0.9	0.1
Aluminium arsenate	0.9	0.1

Discussion of Results.

The M. L. D. of acid lead arsenate for the fourth instar silkworm, 0.09 mg./gram, is the most important constant ascertained in the course of this work, not only because it was checked and rechecked on a large number of insects, but because it characterizes the toxicity of a widely

used compound of known and uniform composition. This constant should be useful for predicting the probable amount of acid lead arsenate which would be required to kill other species of insects even though there may be considerable differences in susceptibility among different species.

The work of Van Leeuwen (10) on the toxicity of acid lead arsenate for the Japanese beetle shows that our M. L. D. for the silkworm could be used to estimate the least amount of this compound necessary to kill the beetle, the mean weight of which is about 0.10 gram. The calculated least dose is, therefore, 0.009 mg. Van Leeuwen found it to be 0.0035 mg. The latter figure may be low, because the poisoned beetles were not given a chance to recover on unpoisoned foliage, as were our silkworms, and malnutrition may have played a part in their death.

What is the least quantity of acid lead arsenate necessary to kill the newly hatched codling moth larva? It is not likely that this question can be answered by direct experimentation, because the insect is so small. Haseman (5) offered known amounts of acid lead arsenate to second or third instar larvae on bits of apple. But he had no means of knowing what part of the dose was taken by the worms. He concluded that 0.0033 mg. was a lethal dose for the smallest worms used. It is almost certain that this is greater than the M. L. D.

The mean weight of the newly hatched codling moth larva is about 0.04 mg., and if the M. L. D. is 0.09 mg./gram as for the fourth instar silkworm, the least amount necessary to kill is 0.0000036 mg. This figure should probably be lower because susceptibility to arsenic decreases with increasing age of larvae, — Campbell (2).

The toxicity of the other compounds compared with acid lead arsenate, runs more or less parallel with their relative effectiveness as determined by field workers.

Our sample of copper cyanide is at least twice as toxic to the fourth instar silkworm as acid lead arsenate. Kirkland (7), searching for stomach-poisons for the gypsy moth caterpillar in 1895, was probably the first to test this compound and reported it to be fairly effective. Only a few desultory tests of it were made by others in later years. Recently it has been tested as a possible substitute for acid lead arsenate in codling moth control, but its injurious effect on foliage has discouraged further investigations. Moore and Campbell (9) were impressed by its effectiveness against the Japanese beetle and the tent caterpillar and by its stability with respect to its CN content.

It is not likely that any two samples of copper cyanide which have been tested as stomach-poisons were chemically identical. Copper cyanide always consists largely of cuprous cyanide, but cupric copper may be present in variable amounts depending on the method of manufacture. Since copper cyanide has been used at times without injury even to bean foliage, it seems possible that cupric copper may have been responsible for foliage injury. The toxicity of pure cuprous cyanide for mammals, insects, and plants should be determined before copper cyanide is discarded as an arenical substitute, because its toxicity to insects is really extraordinary.

Little need be said about sodium, potassium, and barium fluosilicate and cryolite. They are known to be as effective, or nearly as effective,

as acid lead arsenate or calcium arsenate, — Fleming (4), Walker and Mills (11). Their relative toxicity is much the same as their relative effectiveness.

The fact that a basic lead arsenate may be only $^1/_{10}$ as toxic as acid lead arsenate is of some interest, because the basic compounds have long been known to be much less effective than acid lead arsenate and have been dropped from commercial use except in a few situations where acid lead arsenate cannot be applied.

Aluminium arsenate has proved to be disappointing in field and laboratory tests against codling moth. Its low toxicity, $^1/_{10}$ that of acid lead arsenate, accounts for its ineffectiveness.

Turning now to the relative susceptibility of the rabbit and the silkworm to some of the poisons just mentioned, we find (Table 5) that the minimum lethal doses by mouth of acid lead arsenate and sodium fluosilicate are practically the same for the silkworm and the rabbit. Although the minimum lethal doses for the rabbit were determined by other workers using compounds which may have differed somewhat in physical and chemical properties from ours, we conclude that these compounds have no significant factor of safety for rabbits in acute poisoning. We disagree with Marcovitch (8 p. 42) who, on the basis of what we believe to be incomparable data, makes a general statement to the effect that sodium fluosilicate is more toxic to insects than the arsenicals and less toxic to mammals. A thorough analysis of the relative toxicity of acid lead arsenate and sodium fluosilicate with our reasons for disputing Marcovitch's important statement will be given in another paper.

It does not seem likely that any inorganic poison will be found to have a high factor of safety for mammals, but among the more complex organic compounds we may still hope to discover a specific insect stomach-poison.

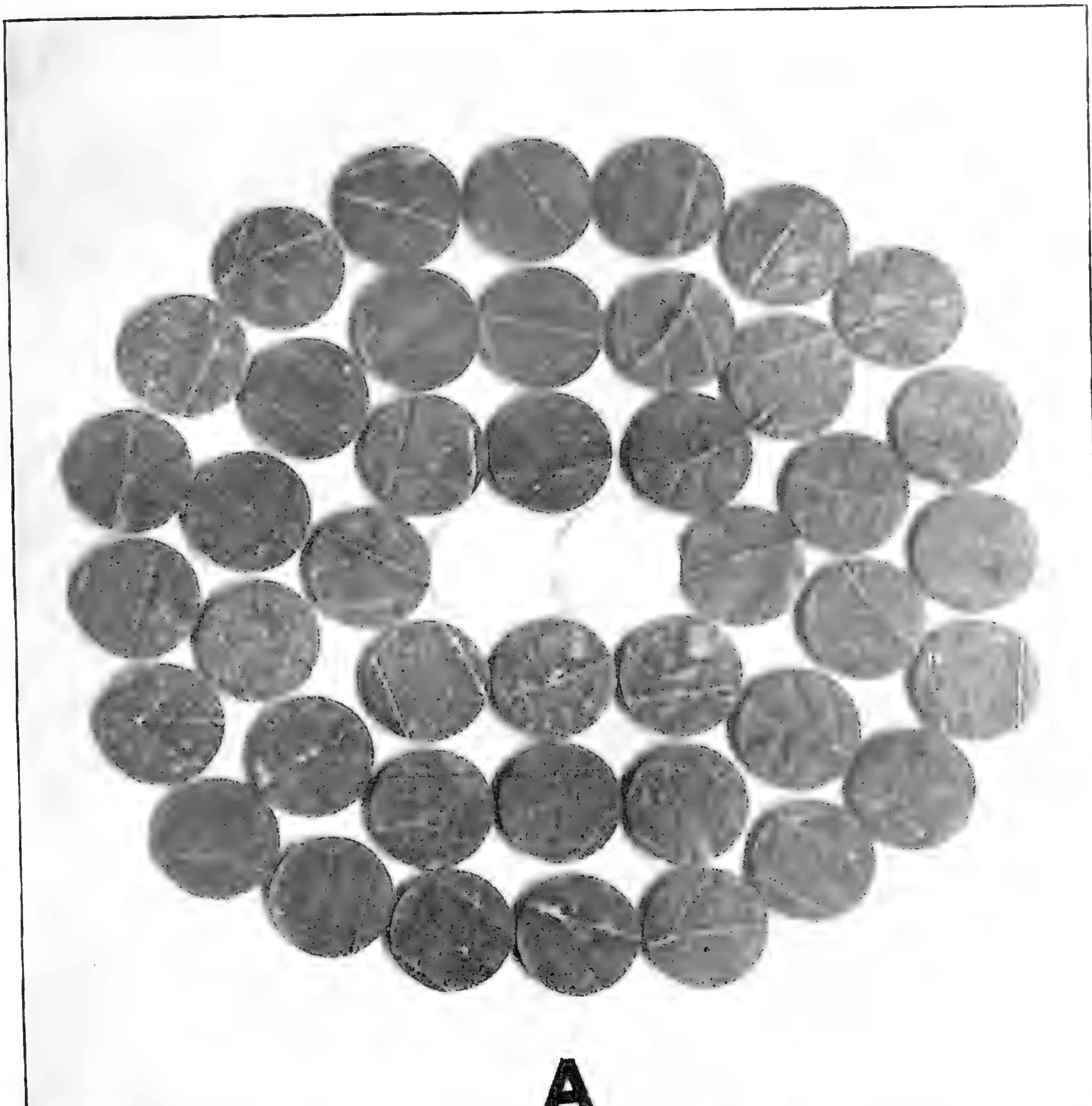
Table 5. — The relative acute toxicity (by mouth) to the rabbit and the 4th instar silkworm of sodium fluosilicate, acid lead arsenate, basic lead arsenate, and sodium arsenate. M. L. D. in mg./gram.

	Rabbit	Observer	Silkworm	Observer
Sodium fluosilicate	0,12	Marcovitch (8 p. 15)	0,09	Campbell & Filmer
Acid lead arsenate	0,10	Schwartze & Munch*)	0,09	Campbell & Filmer
Basic lead arsenate	0,18	Fabre (3 p. 73)	0,9	Campbell & Filmer
Sodium arsenate	0,05	Fabre (3 p. 73)	0,05	Campbell (2 p. 729)

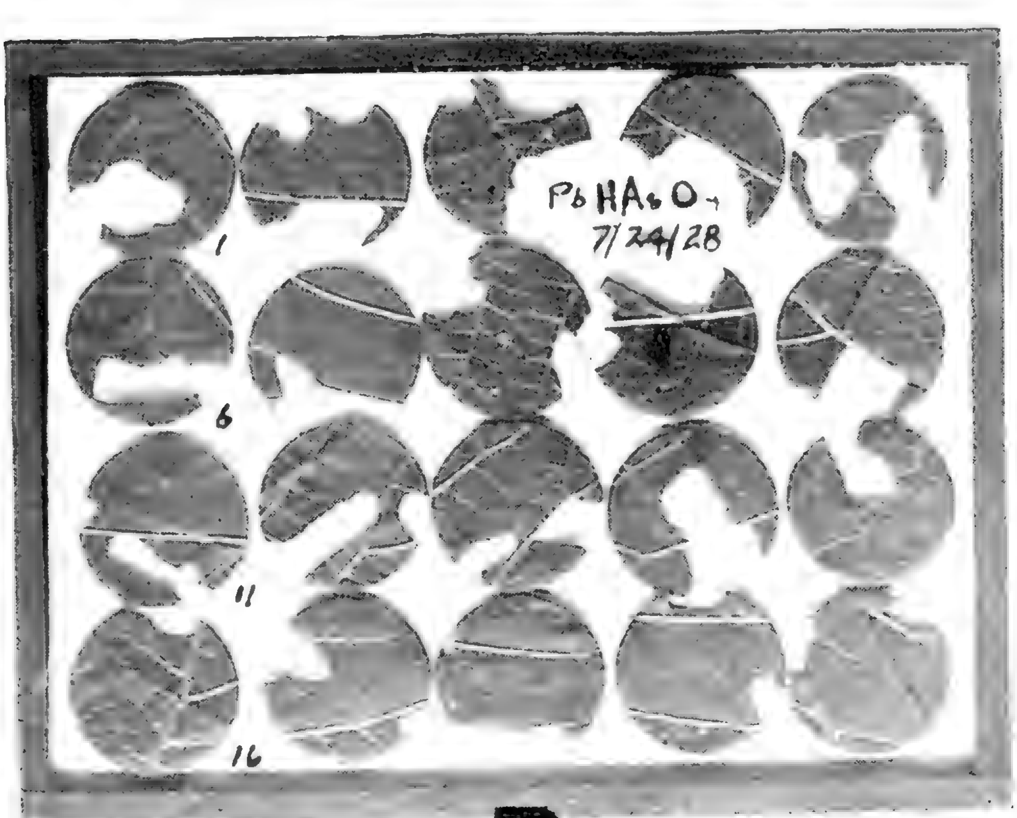
Summary.

A method is described for estimating the minimum lethal doses of commercial stomach-poisons for a laboratory insect, the silkworm. The figures so found provide a quantitative measure of the relative toxicity of the respective compounds for the silkworm. They may also be used to estimate the least amount of a compound required to kill individuals of other species

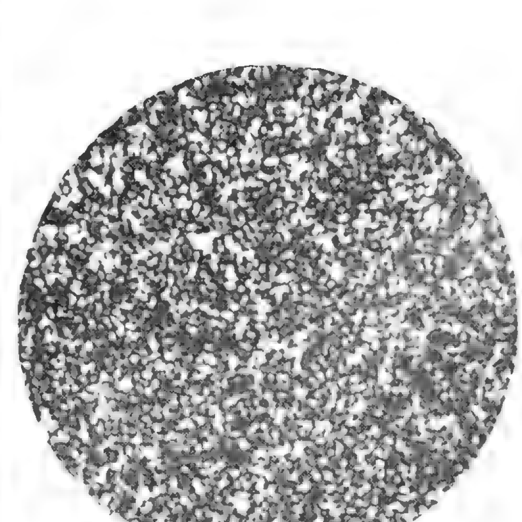
*) Unpublished estimate of E. W. Schwartze and J. C. Munch, formerly of the Bureau of Chemistry, U. S. Dept, of Agriculture. The M. L. D. may be greater than 0.10 mg./gram. depending on the size of the particles of acid lead arsenate.



A



B



C

of insects, provided the mean weight of the individuals is known. For example, since the M. L. D. of acid lead arsenate for nwly hatched codling moth larvae is probably equal to or less than that for the fourth instar silkworm, 0.09 mg./gram, the amount of this compound required to kill a larva, mean weight 0.04 mg., would be about 0.000004 mg.

When compared with minimum lethal doses of the same compounds for a mammal, the foregoing figures make possible an estimation of the relative susceptibility of an insect and a mammal to the same stomach-poison. So it was found that neither acid lead arsenate nor sodium fluosilicate have any significant factor of safety for the rabbit; i. e., their acute toxicity to the rabbit and the silkworm appears to be equal.

Literature.

1. Campbell, F. L. — 1926. Speed of toxic action of arsenic in the silkworm; in Journ. Gen. Physiol. 9, pp. 433—443.
2. — 1926. Relative susceptibility to arsenic in successive instars of the silkworm; ibid., pp. 727—733.
3. Fabre, H. — 1913. Essais sur les toxicités de quelques composés arsenicaux utilisés en agriculture; in Ann. Service Epiphyties 1, pp. 63—76.
4. Fleming, W. E. — 1927. Fluosilicates as insecticides for the Japanese beetle; Journ. Econ. Ent. 20, pp. 685—691.
5. Haseman, L. — 1923. Amount of arsenic placed in calyx cups and lethal dosage for apple worm; ibid., 16, pp. 270—275.
6. Janisch, R. — 1926. Eine neue Methode zur vergleichenden Beurteilung der Wirksamkeit von Insektenfraßgiften; in Nachrichtenbl. Deut. Pflanzenschutzdienst 6, pp. 18—20.
7. Kirkland, A. H. — 1895. Report on insecticides for control of gypsy moth; U. S. D. A. Div. Ent. Bul. 2 New Ser., p. 67.
8. Marcovitch, S. — 1928. Studies on toxicity of fluorine compounds; Univ. Tenn. Agr. Expt. Sta. Bul. 139, 48 p.
9. Moore, W. and Campbell, F. L. — 1924. Studies on nonarsenical stomach-poison insecticides; in Journ. Agr. Research 28, pp. 395—402.
10. Van Leeuwen, E. R. — 1927. A study of the toxicity of acid lead arsenate on the Japanese beetle (*Popillia japonica* Newm.); ibid., 34, pp. 1043—1047.
11. Walker, H. W. and Mills, J. E. — 1927. Chemical Warfare Service boll weevil investigation progress report; in Indust. and Engin. Chem. 19, pp. 703—711.

Explanation of Plate IV.

A. Arrangement of leaf disks on glass plate to be covered by a uniform layer of dust. Cover glasses in center.

B. Partially consumed poisoned sandwiches as arranged between glass plates for photographic enlargement.

C. Photomicrograph of an acid lead arsenate deposit, 0.031 mg./sq. cm., showing its uniformity.

Experimental Studies on the Effect of "Kambara" Earth upon the Double Cocoon Formation in the Silkworm.

Shujiro Inomata,
Sericultural Laboratory, College of Agriculture, Tottori, Nippon.

The double cocoon is formed when two larvae of the silkworm spin a single cocoon and pupate within.

Due to the number of factors affecting the formation of double cocoons, the percentage of the double cocoon formed is not always the same. However, it is estimated that if the present percentage of double cocoons could be reduced to one-third, the value of the total silk crop of the Empire would be increased annually by more than eight million dollars. Therefore, the control of double cocoon formation is a very important problem in our country.

In order to control the double cocoon formation, various forms of powders have been used by silkworm growers. Our present experiment was carried on by using one of the powders known as "Kambara" Earth in order to determine whether or not these powders actually did control the double cocoon formation, and also to determine whether they exerted any injurious effects upon the silkworm cocoons ("Kambara" Earth is similar to Fuller's Earth or Florida Earth).

The following is a brief summary of the results of the experiment with the hybrid between the Chinese and Japanese breeds:

1. The use of "Kambara" Earth decreased the double cocoon formation to one-fourth of the untreated.

2. "Kambara" Earth was effective in the control of double cocoon formation in this hybrid.

3. Waste cocoons *), however, increased by 50% as compared with the untreated.

4. Although the "Kambara" Earth decreased the number of double cocoons, it also reduced the quality of the cocoons, by forming "hafunuke" (uneven) and "usukawa" (thin-layered) cocoons.

5. Since "Kambara" Earth has these defects, it does not seem to be of practical value in the control of double cocoon formation.

6. However, when compared to several other similar powders, the "Kambara" Earth proved to be the most effective in reducing the number of double cocoons.

---

*) Waste Cocoons include thin layered, unevenly layered, fluffy, stained, and irregularly formed cocoons.

It may be of interest to mention here that there is another method employed in Nippon of controlling double cocoon formation. It is by placing the immature larvae instead of mature larvae into the cocoon holders. This method is effective, because the worms do not all begin to spin at the same time, but begin to spin separately. However, in this case the quantity of the thread is somewhat reduced. Therefore, this method is also not to be recommended for an economical control of double cocoon formation.

A possible solution of the problem seems to be in the breeding of a hybrid by using a variety which does not produce any double cocoons, such as the polyvoltine breed of Canton, China. However, this is yet to be determined in the future.

The Origin of Geographical Varieties in Coccinellidae.

Th. Dobzhansky,

University Laboratory for Genetics, Leningrad, U. S. S. R.

Abstract.

The author studied statistically the variability of color patterns in the Palearctic species of *Coccinellidae* (chiefly subfam. *Coccinellinae*). Many species of this family present large series of variations, which are, as far as studied, hereditary.

The geographical distribution of different varieties of a given species inside the area occupied by the species is very suggestive. There are, beside true subspecific forms, restricted to a definite geographical area, and beside non-geographical forms (aberratio), also all kinds of intermediate conditions. The study of those intermediate conditions is perhaps the most important problem, because it shows clearly that the non-geographical and the geographical variation are not such different phenomena as is often considered to be the case.

A few examples may be mentioned here. The European population of *Adonia variegata* Goeze is chiefly composed of varieties having little black pigment in the elytra, varieties having more pigment are less common. In East Siberia the same species is represented chiefly by dark varieties, but lighter ones are also found. The difference between the European and the Siberian populations can be expressed only in terms of average frequencies of several varieties.

In East Siberia, China, Japan and Korea are found no less than four varieties of *Harmonia axyridis* Pall., no variety being clearly predominant; but in West Siberia more than 99% of the individuals are the typical variety *axyridis*, with exceptional individuals like the Eastern varieties.

In *Hippodamia 13-punctata* L. two distinct subspecies exist: *13-punctata* living in Europe and Siberia and *signata* Fald. living in the Caucasus and Turkestan. Nevertheless, very rarely *signata* occurs also in Europe, and true *13-punctata* may be found both in the Caucasus and Turkestan.

The origin of geographical varieties may be considered as the result of a process of differentiation from primary mixed population within a species. All the stages of this process can be found among existing species.

Clysia ambiguella Hübn. und *Polychrosis botrana* Schiff. im deutschen Weinbaugebiet.

Dr. Fritz Stellwaag,

Staatl. Lehr- und Versuchsanstalt für Wein- und Obstbau, Neustadt a. d. Hdt.

(Mit 6 Textfiguren.)

Deutschland treibt Weinbau namentlich im klimatisch bevorzugten Westen und zwar im Verlaufsgebiet des Rheins und einiger seiner Nebenflüsse. Preußen ist daran an den Ufern des Rheinstromes selbst, an der Mosel, Saar und Ruwer mit rund 16 000 ha beteiligt. Das hessische Weinbaugebiet breitet sich besonders über die Hänge der an das linke Rheinufer stoßenden Bergerhebungen und kommt an Umfang dem Preußens gleich. Ueber die größte Fläche verfügt zur Zeit Bayern mit fast 20 000 ha, von denen $^4/_5$ in der Rheinebene zwischen der hessischen und elsässischen Grenze liegen, während $^1/_5$ auf die Hänge des Maines in der Umgebung von Würzburg trifft. Das Weinbaugebiet von Baden in der Zone östlich der französischen Grenze und des Oberrheines umfaßt zur Zeit über 12 000 ha, das von Württemberg (hauptsächlich am Neckar) über 10 000 ha.

Als Hauptertragsschädling des Rebstockes gelten die Traubenwickler *Clysia ambiguella* und *Polychrosis botrana.* Je nach den einzelnen Jahren kommt die eine oder andere Art massenhaft vor, so daß ihre Bekämpfung zu einer Lebensfrage des Weinbaues geworden ist. Sie erscheinen beide in zwei Generationen. Die Beschädigung der Frühjahrsbrut besteht darin, daß zahlreiche Blütenknospen angefressen und versponnen werden. Die Raupen der Sommergeneration bohren sich in die Beeren ein und höhlen sie bis auf die Kerne aus. Aber auch Beeren, die nur leicht benagt werden, erleiden erhebliche Beschädigungen, da durch die Wunden zerstörende Pilze und Bakterien eindringen.

In der Schadenwirkung stimmen also beide Arten weitgehend überein, auch in großen Zügen der Lebensweise. Unterschiede bestehen jedoch vor allem in gewissen Lebensäußerungen und in der verschiedenen Empfindlichkeit gegen Witterungseinflüsse. Sie lassen sich in ihren wichtigen Punkten folgendermaßen kurz ausdrücken:

Clysia ambiguella

1. Falter Nachttier.
2. Raupe träge.
3. Optimale Lebensbedingungen in weniger hohen Temperaturen, sogar bei Kühle und Feuchtigkeit.
4. Flugzeiten meist wohlbegrenzt.

Polychrosis botrana

1. Falter Dämmerungstier.
2. Raupe sehr lebhaft.
3. Optimale Lebensbedingungen bei hohen Temperaturen und Trockenheit.
4. Flugzeiten meist verzettelt.

Über die Biologie der beiden Arten liegen zahlreiche Beobachtungen vor, da ihr seit Jahren im ganzen europäischen Weinbaugebiet die größte Beachtung entgegengebracht wird. Ausschlaggebend für den Massenwechsel und die Bekämpfung ist jedoch die Erscheinungszeit der Falter von Generation zu Generation und von Jahr zu Jahr. Hierzu habe ich zusammen mit meinem Mitarbeiter L. Sprengel seit einigen Jahren umfassende epidemiologische Studien angestellt, über deren Ergebnis hier zusammenfassend berichtet sei.

Besonders geeignet für epidemiologische Untersuchungen ist das Weinbaugebiet der Rheinpfalz. Es liegt als geschlossenes Gebiet in der Ebene am Ostrand des Haardtgebirges. Je nach der Örtlichkeit wechselt die druchschnittliche Jahrestemperatur zwischen 9 und 11° C, liegt also gerade in der Temperaturspanne, die für Übervermehrungen beider Arten günstig ist. Dazu kommt noch große Trockenheit und Mangel an längeren Regengüssen. Da außerdem Vögel und Parasiten in der Dezimierung des Schädlings so gut wie keine Rolle spielen, sind die Beobachtungsbedingungen einfacher als bei anderen Kalamitäten. Man darf von vornherein annehmen, daß die Entwicklung der Übervermehrungen von äußeren Faktoren weitgehend beeinflußt wird. Dies bestätigten zunächst unsere vorläufigen Untersuchungen in einzelnen Weinlagen.

Zur Erweiterung unserer eigenen Beobachtungen wurden 1926 Beobachter aufgestellt, die an 72 Orten nach einem bestimmten Plan arbeiten. Sie hängen in den Weinbergen Fanggläser mit Lockflüssigkeiten auf und stellen Tag für Tag die Zahl der gefangenen Falter fest. Die Auswertung der Befunde erfolgt in Tabellen oder Kurven. Gegenwärtig (1928) wird die Fanggläsermethode an etwa 500 Orten des pfälzischen Weinbaugebietes mit Hilfe der Bürgermeisterämter und Feldschützen amtlich durchgeführt. Die Zahl der Beobachtungsgläser beträgt über 3000. Unsere Aufgabe besteht darin, die Analyse der Erscheinungen vorzunehmen und Schlußfolgerungen daraus zu ziehen. Die Analyse macht dann besondere Schwierigkeiten, wenn zu viele Faktoren, die zur Erscheinungsform der Flugbilder führen, berücksichtigt werden müssen. Sie sind oft nicht alle mit Apparaten meßbar, wie es für exakte Untersuchungen gefordert wird. Es kommt aber nicht allein auf die Faktoren im einzelnen an, sondern auf ihr Zusammenwirken. Im Jahre 1921 machte ich darauf aufmerksam, daß die Umweltbedingungen kausal in einer Kette zusammenhängen, so daß ein Glied das andere und erst mittelbar das Ergebnis beeinflußt. Es mußte daher zunächst darnach gestrebt werden, möglichst wenig komplizierte Verhältnisse zu studieren.

Besonders klare Einsicht gibt der Vergleich solcher Beobachtungen in einem enger begrenzten Gebiet, das sich durch Einförmigkeit des Geländes, Einheitlichkeit der Rebenerziehung, gleiche klimatische Lage und möglichst gleichmäßiges Auftreten des Schädlings auszeichnet. Nicht leicht wird ein solches Gelände gefunden. Es verspricht aber die besten Ergebnisse, da man in ihm am klarsten, fast wie im Laboratorium, den örtlichen und zeitlichen Einfluß der Witterung auf den Schädling studieren kann. Erst mit Kenntnissen nach dieser Richtung kann man an die Auswertung der unter verschiedenen Bedingungen gewonnenen und daher schwerer zu analysierenden andern Beobachtungen gehen.

Im folgenden teile ich als Beispiel aus einem ungewöhnlich umfangreichen Material die Feststellungen in drei benachbarten Lagen aus einem unseren Anforderungen entsprechenden Ausschnitt des pfälzischen Weinbaugebietes in zwei aufeinanderfolgenden Jahren mit. Es handelt sich hier nur um *Clysia ambiguella.*

Ein Überblick über die sechs Kurven zeigt zunächst, daß sie nach Beginn, Stärke, Ende und Art der Flüge weitgehend verschieden sind, obwohl es sich um eng benachbarte Orte handelt, die in hohem Maße unter gleichmäßigen Bedingungen stehen.

In der Lage Hütt (Textfig. 1) liegt 1926 der Falterflug der Generationen Anfang Mai und Ende Juli, 1927 (Textfig. 2) aber Ende Mai und Ende Juli. Ein ähnliches Bild zeigen die Kurven der Lage Krummland (Textfig. 3 und 4), doch unterscheidet sich diese von der Lage Hütt durch verschiedene Stärke der Flüge. In der Lage Erbecher (Textfig. 5 und 6) geht 1926 der Flug der ersten Generation langsam in den der zweiten über, während 1927 die Generationen deutlich getrennt sind. Zudem unterscheiden sich beide Kurven durch die verschiedene Stärke der Flüge.

Es ist notwendig die Flugbilder mit den Aufzeichnungen des Wetterdienstes zu vergleichen. Da sie an anderer Stelle gegeben wurden, kann ich hier auf die Einzelheiten verzichten. Im ganzen ergibt sich, daß die jeweilige Besonderheit der Flüge von Tag zu Tag unter den gegebenen Verhältnissen einzig und allein auf die wechselnde Wetterlage zurückgeführt werden muß. Es zeigte sich auch, daß *Clysia ambiguella* von den physikalischen Faktoren durch Regen wenig beeinflußt wird. Den Hauptbegrenzungsfaktor bildet die Temperatur. Kühle Nächte können den Flug geradezu abhacken, warme steigern die Zahl der Falter außerordentlich.

Das Klima spielt nur eine allgemein regulierende Rolle, indem es das Auftreten der Art überhaupt regelt.

Einen ganz geringen Einfluß übt die Zahl der in der vorhergehenden Generation vorhandenen Individuen aus. Sonst könnte nicht auf einen starken Flug ein schwacher oder auf einen schwachen ein starker folgen. In jedem Fall müßte eine progressive Steigerung festgestellt werden.

Die Temperatur beeinflußt nicht nur die Art des Flugbildes, sondern die Entwicklung der Kalamität, d. h. das Auftreten der schädigenden Raupen als Masse. In den Beobachtungsgläsern erscheinen meist zuerst Männchen. Wird um diese Zeit wie in der Lage Erbecher 1926 der Flug für längere Zeit unterbrochen, so leidet auch die Begattung und Eiablage, und damit die Zahl der sich entwickelnden Raupen. Die Einwirkung von Kühle während der Flugzeit führt zur Aufsplitterung während des Fluges, so daß als Folge davon immer neue Schübe von Eiern und Räupchen nachkommen. In extremem Fall sind dann Eier, Raupen, Puppen und Falter gleichzeitig vorhanden. Hohe, gleichmäßige Nachttemperaturen führen umgekehrt zu einem raschen Anstieg und steilen Abfall der Kurven ohne Aufsplitterung. Infolgedessen erfolgt die Eiablage in wenigen Tagen in größter Menge und die Zeit des Vorhandenseins der Raupen schließt sich unmittelbar einheitlich an.

Der Einfluß der Temperatur während des Fluges in bezug auf die Kalamität ist also ganz besonders ein Einfluß auf die Eiablage.

Fig. 1.

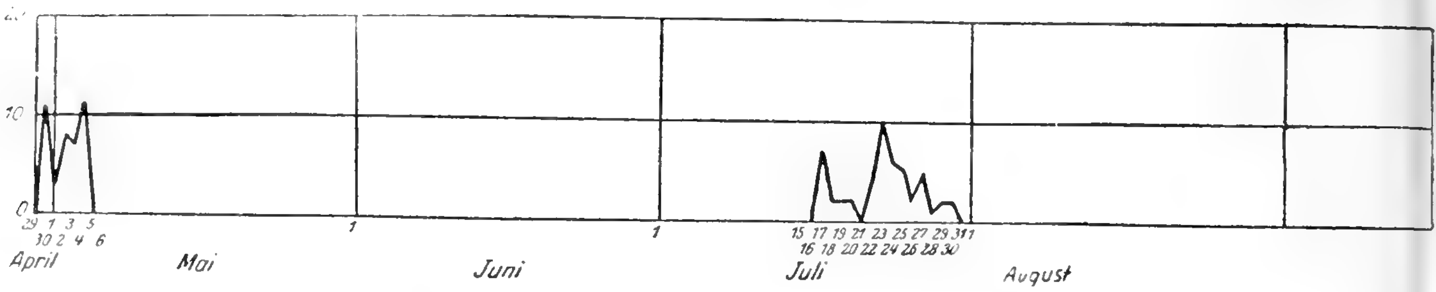


Fig. 2.

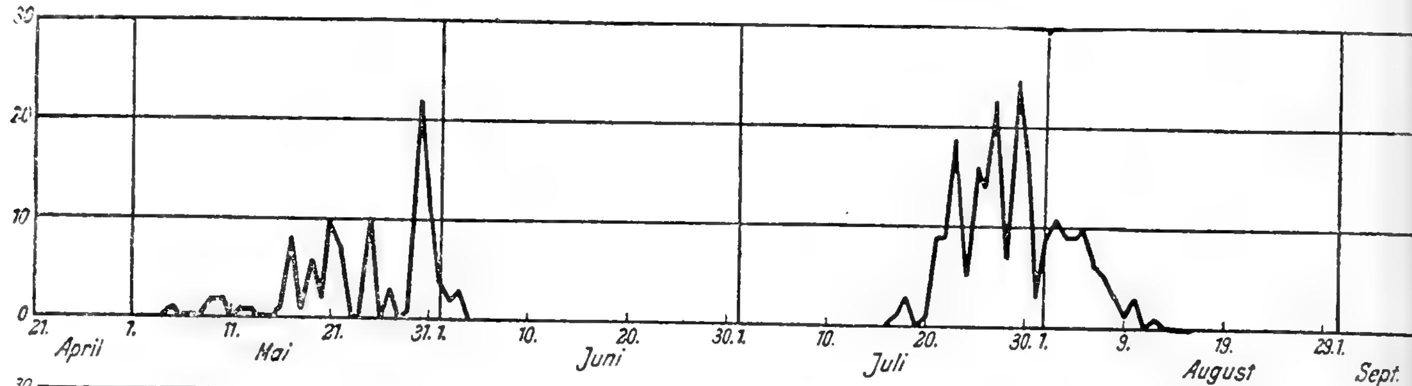


Fig. 3.

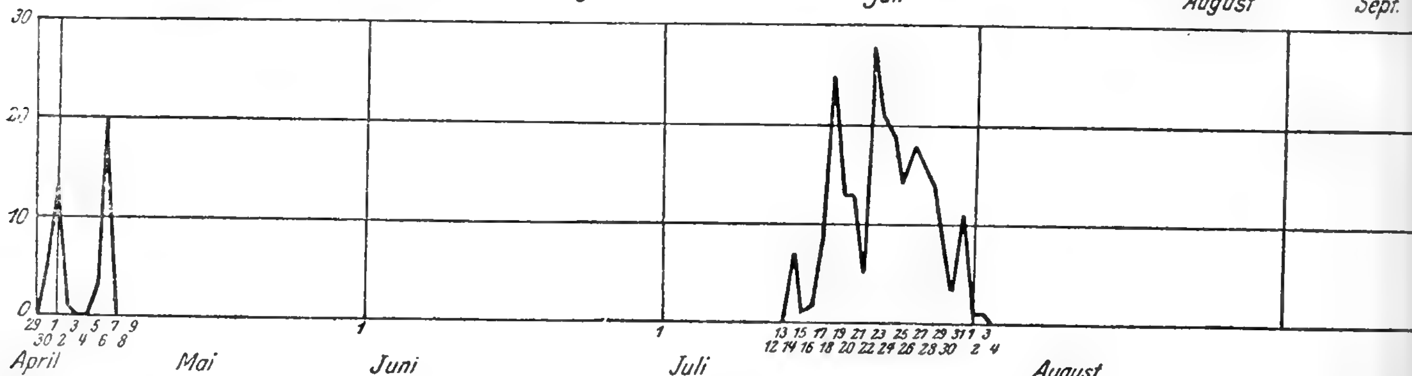


Fig. 4.

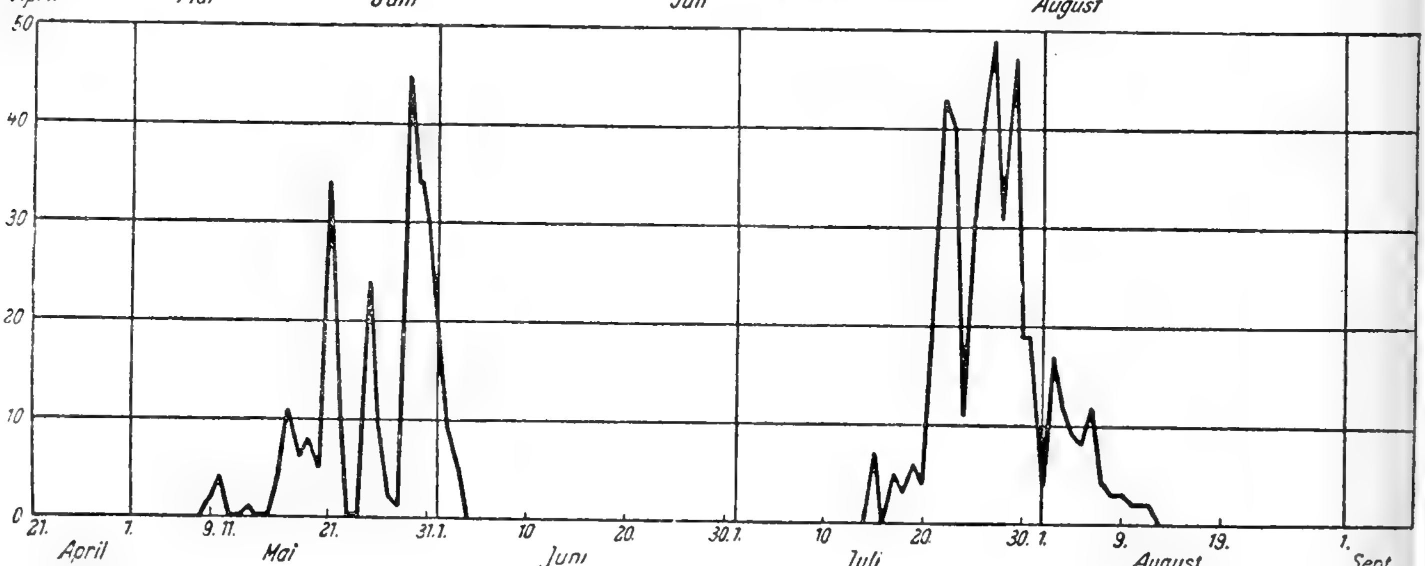


Fig. 5.

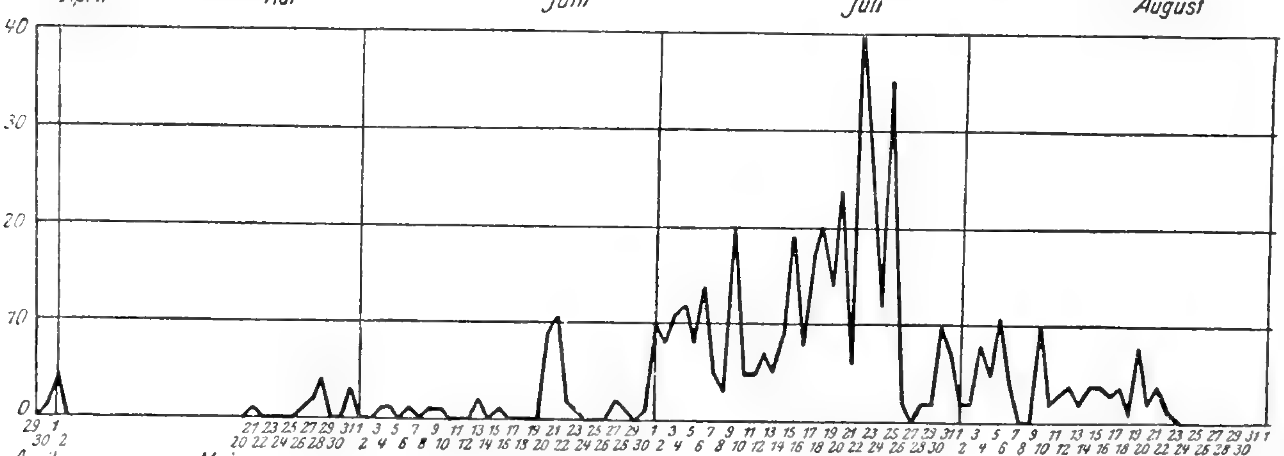
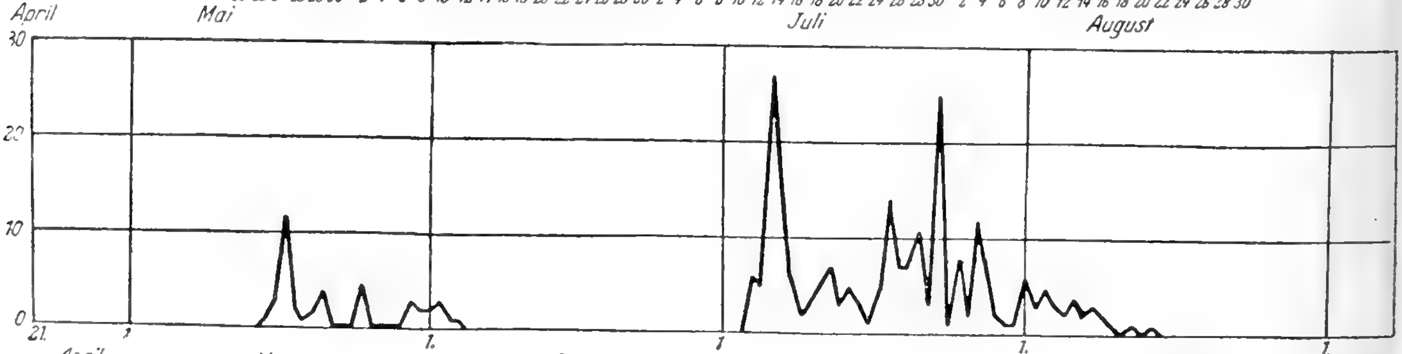


Fig. 6.



Daher war die Frage zu klären: Wann beginnt die Eiablage während der Flugzeit und wann ist sie beendet? Hierüber liegen von S p r e n g e l Befunde vor.

Zur Erläuterung bringe ich eine Tabelle aus der Gegend von Neustadt 1927, die neben der Epidemiologie den Zustand der Eier in den Ovarien berücksichtigt.

Verhältnis von Männchen und Weibchen und Reifezustand der Eier.

Datum	Männchen	Weibchen	Eier nicht entwickelt	Eier entwickelt	Eier abgelegt
13. 7. 27	1	1	1	—	—
14. 7. 27	6	11	8	3	—
15. 7. 27	22	13	3	10	—
16. 7. 27	3	1	1	—	—
17. 7. 27	31	50	11	38	—
18. 7. 27	28	42	—	42	—
19. 7. 27	6	12	—	12	—
20. 7. 27	2	7	—	7	—
21. 7. 27	16	39	9	30	—
22. 7. 27	14	16	—	5	16
23. 7. 27	12	16	—	—	11
24. 7. 27	1	3	—	—	3
25. 7. 27	10	13	3	3	7
26. 7. 37	2	5	1	—	4
27. 7. 27	3	6	—	1	5
28. 7. 27	1	3	—	—	3
29. 7. 27	2	10	—	2	8
30. 7. 27	1	4	—	—	4
31. 7. 27	—	3	—	—	3
1. 8. 27	—	4	—	—	4
2. 8. 27	—	—	—	—	—
3. 8. 27	1	2	—	—	2
4. 8. 27	—	4	—	—	4
Summa:	173	244	37	153	74

Es zeigte sich, daß in der Zeit vom 13. bis 18. Juli die Ovarien durchweg ganz unentwickelte Eier enthielten. Somit konnten, bevor sich die Falter gefangen hatten, noch keine Eier abgelegt worden sein. Vom 17. Juli ab erhielten wir Weibchen mit völlig reifen Eiern und der Zustand der Eierstöcke zeigte, daß bereits Ablagen erfolgt waren. Vom 22. Juli ab waren ausschließlich solche Weibchen in den Gläsern vertreten, die sich ihrer Eier bereits entledigt hatten. Es können also mehrere Tage vergehen, bis die Weibchen zur Eiablage schreiten. In dieser Zeit findet die Begattung statt. In den Nächten, in denen sich die meisten Falter in den Gläsern fanden, wurden auch die meisten Eier abgelegt. Nach dem zweiten Drittel des Fluges war die Eiablage beendet. Die nach dieser Zeit, also in der Tabelle nach dem 29. Juli vorhandenen Falter sind daher für die Beurteilung des Zeitpunktes der Bekämpfung praktisch von ganz untergeordneter Bedeutung gewesen. Der Inhalt der Gläser zeigt auch, daß Weibchen sowohl vor, während und nach der Eiablage die Fanggefäße aufsuchen.

Die Tabelle veranschaulicht noch eine weitere Tatsache. Wenige Tage hindurch vom 13. bis 16. Juli war die Zahl der Männchen derjenigen der Weibchen überlegen, eine Erscheinung, die bei Schmetterlingen aufzutreten

pflegt und allgemein bekannt ist. Vom 17. Juli ab, dem Zeitpunkte des stärksten Fluges an, wurde sie aber von der der Weibchen noch übertroffen. Von da ab überwogen die Weibchen in allen Fängen. Niemals konnten wir nachweisen, daß sich viele Männchen um ein einziges Weibchen oder mehrere scharten, woraus hervorgeht, daß offenbar der Lockreiz der Fangflüssigkeit hier stärker ist, als derjenige der Weibchen auf die Männchen.

Daraus ergibt sich, daß das Flugbild in Verbindung mit der Temperatur Aufschluß über Beginn, Stärke und Ende der Massenbewegung gibt, und daß die Art der Kalamität von der Beeinflussung der Begattung und Eiablage abhängt.

Die Unmöglichkeit, die physikalischen Faktoren mit Sicherheit über eine Zeit von drei Tagen vorauszusehen, bringt es mit sich, daß auch eine Prognose der Epidemiologie vorerst nicht möglich ist. Unsere Studien aber bringen theoretische Anhaltspunkte für die Klärung epidemiologischer Fragen als solcher. Sie führen aber auch praktisch zu einer gewissen Sicherheit in der Bekämpfung dadurch, daß jeder einzelne mit Hilfe der Fanggläsermethode in der Lage ist, den jeweiligen Zeitpunkt der Bekämpfung festzulegen. So gibt die Fanggläsermethode die Grundlage für eine Rationalisierung der Bekämpfung ab und bedeutet insofern eine wichtige wirtschaftliche Maßnahme.

Literatur.

1. Stellwaag, F. — Die Schmarotzerwespen als Parasiten. Verlag Parey, Berlin 1921.
2. — — Die Massenbewegung der Traubenwickler im Verhältnis zur Witterung; in Anzeiger für Schädlingskunde, 1925.
3. — — Forschungen über die Epidemiologie des Heu- und Sauerwurmes; in Verhandl. deutsch. Gesellsch. für angewandte Entomologie 1926, Berlin, 1927.
4. — — Epidemiologisch statistische Untersuchungen, etc.; in Anzeiger für Schädlingskunde, 1928.
5. Sprengel, L. — Untersuchungen über die Gradation des Heu- und Sauerwurmes; ibid., 1927.
6. — — Versuche zur Rationalisierung der Heu- und Sauerwurmbekämpfung im pfälzischen Weinbau; in Der deutsche Weinbau, 1927.

The Evolution of the Order Odonata.

Dr. R. J. Tillyard, Canberra, Australia.

(Abstract.)

Many years of study of the Order Odonata has convinced me that the larval wing-tracheation, while corresponding in general with the imaginal venation, cannot be relied upon to determine the veins in every detail. In particular is this the case with the vein which Needham originally called Rs and which I later on termed Ms. In the Anisoptera, the trachea of this vein crosses over two branches of the vein which Needham terms the media, M. In Zygoptera, it is always supplied by a branch trachea from this vein M, without any crossing over. But the origin of this trachea differs in different groups; in *Lestidae* the trachea starts far distad, leaving a long basal portion of the vein, called the "long bridge", destitute of a trachea: in most Zygoptera the trachea comes off from M at the same point as the vein, so that there is no bridge at all: and in some larvae of *Synlestes,* the trachea actually arises from the branch of M posterior to Ms.

The fact that there are four different sources of supply for the trachea of vein Rs or Ms strongly suggested to me that it was the tracheation that was variable, not the vein. When the Upper and Lower Permian Odonata were discovered, they all turned out to be exceedingly primitive Zygopterous forms allied to *Hemiphlebia* and *Chorismagrion* of Australia to-day, with the discoidal cell open basally and a very primitive type of nodus and arculus. I therefore studied the condition of the so-called Rs or Ms in these types, and discovered at once that it was not a true primitive vein, but an interpolated vein of the same type as M_{1A} of Needham, with a Y-vein connection to the two veins anterior and posterior to it. As M_{1A} has no trachea, I argued that, in the most primitive larval form, Rs or Ms should not have a trachea either. Last year I revisited Australia and was enabled to make an expedition to the original locality where I discovered *Hemiphlebia mirabilis* Selys more than twenty years ago, and took over fifty larvae of it there. Dissections of these show that the so-called Rs or Ms has no trachea in that larva, nor has M_{1A}, nor has the vein called M_4 by Needham, nor the vein 1A. In fact, only R and the concave veins possess tracheae.

If this is an indication of the primitive type of venation, it is too far back for the fossil record at present. But we have to note that all the Megasecoptera and Palaeodictyoptera have Rs with only concave branches, and that, in the Protodonata, Odonata and Plecoptera, convex veins are interpolated between them. It therefore follows that the ancestral Order from which these three more specialized Orders have been derived must have a

radical sector of this type. In looking for the ancestor of the Odonata, we have to find something close to the Permian types, i. e. with only a single anal vein and also a petiolate or subpetiolate base. Another character which may give us valuable guidance is that the wing is hairless and the costa is strongly serrated along its outer edge.

The Megasecoptera being the only Order with a single anal vein, and many of the forms having petiolate or subpetiolate wings, I conclude that they must be the ancestral Order. Further, the Carboniferous genus *Brodiea* has the strongly serrated costa, and also a small humeral hump suggestive of the beginnings of a precostal area such as is found in Protodonata. The venation of the last larval instar of *Brodiea* is known as well as that of the imago; between the two lies a hypothetical type which I call *Protobrodiea,* having only two descending concave branches of Rs, which is exactly the type needed for us to develop evolutionarily the whole series of Protodonata and Odonata. The Protodonata are a side-branch, starting with *Campyloptera* in the Upper Carboniferous and having two families, the *Protagriidae (Protagrion, Calvestiella)* with the true Rs still distinct and the *Megansuridae (Megansura, Megatypus, Typus,* etc.) with Rs and MA fused and MP and Cu_1 already reduced. The stages of evolution of true Odonata are a hypothetical *Protokennedya in* the Carboniferous, from which the Protodonata branched off as a high specialization, followed by the actual fossil form *Kennedya* itself in the Lower Permian, then by the slightly more specialized *Permagrion* and allied unnamed forms in the Upper Permian. These latter are the first true Zygoptera, and they all have petiolate wings, two antenodals, and an open discoidal cell.

Living remnants of this group are the genera *Chorismagrion* and *Hemiphlebia* of Australia. The next stage is the closure of the discoidal cell to form a complete quadrilateral, with completion also of the subnodus, and recession of the branches of Rs basad. Following on that line comes a whole succession of Zygopterous forms in which the general tendency is for fore and hind wings to remain similar, but the anal area to grow and to eliminate the petiolation. It is therefore logical to group the Suborder into the two main divisions or superfamilies of *Coenagrioidea,* retaining the primitive condition of two antenodals, and *Agrioidea,* with more than the original two, provided we remember that there are some annectant types still in existence between them. The culmination of the Zygopterous line lies in the brillant *Agriidae* or *Calopterygidae* of De Selys.

Far back in the Trias, in a group of genera not far removed from *Hemiphlebia,* a tendency set in for the hind wing to develop ahead of the fore. The first differentiation was that the quadrilateral of the hind wing became closed basally, while that of the fore remained open. Next the forewing quadrilateral tended to narrow and bend transversely to the wing, while the hindwing quadrilateral widened as the wing widened. The Triassic and Liassic forms which show this tendency more and more developed as placed in the intermediate Suborder Anisozygoptera, of which only the genus *Epiophlebia* is living at the present day. No true Anisoptera can be proved to have lived in the Liassic, but the Upper Liassic genus *Gomphites,* represented by a hindwing only, is very close to the existing Petalurid genus *Tachopteryx.* Probably it still had a simple quadrilateral

in the forewing, and was therefore not *Tachopteryx* itself, but its immediate ancestor.

There can be no doubt that the true Anisoptera are derived from the Anisozygoptera of the *Gomphites* type, and that they first appeared in the Jurassic, being represented then by a large number of Petalurid and Gomphid types. As a side-branch from the *Petaluridae*, the *Petalia*-group developed, and the uncoloured extinct forms of this group gave origin to the *Aeschnidae*. Another side-branch from the *Petaluridae* was ancestral to the *Cordulegasteridae*, and those forms in which differentiation between fore and hind wing quadrilaterals was most highly developed evolved into the *Corduliidae* with the *Libellulidae* as a specialized sidebranch. This latter has by now become the most highly successful evolutionary effort of the whole Order.

Discussion.

J. G. Needham: — It is a new and very interesting theory that Dr. Tillyard has presented with the clearness that characterizes all his work. Before accepting it, I would like to be further assured on several points.

1. Is the wing with narrowly petiolate base primitive? When we recall the way insect wings develop as broad triangular flaps of integument, this petiolation would not be expected near the foot of the series. Moreover, the slant of the side pieces of the thorax is greater in those Zygoptera which have the longer petiolation; and this I have taken as a sign of specialization. It is at least a departure from the insect norm.

2. Is the open venation with only a few crossveins primitive? When we recall the way the veins are formed by segregation of hpyodermal cells, we could hardly expect to find that segregation completest near the foot of the series. May it not be that Dr. Tillyard's earlier theory of the primitive "archedictyon" is nearer the truth?

3. Is it a valid argument that because a fossil is old it is therefore primitive? May it not be that these fossils merely show that a highly specialized type is very ancient. Nor does the predominance of this one type in particular beds seem at all conclusive while so little evidence from fossils is available.

Evidence for the theory has been adduced (1) from venation, (2) from fluting (alternation of convex and concave veins), and (3) from tracheation. Corroborative testimony is always most convincing if valid. The veins have doubtless been accurately traced by Dr. Tillyard; for his venation figures have always been of the highest standard of excellence. We can accept the facts of alternating veins also as sufficiently stated; but we are as yet entirely lacking any careful study of fluting made to determine the limits of its validity; and systems heretofore based upon it (like that of Adolph) have been shown to be full of vagaries. The tracheation Dr. Tillyard has not shown. He has stated that it is scanty. And we know that reduced tracheation is always most erratic and undependable as evidence of homologies. The corroborations claimed are thus less convincing than they might otherwise be. More facts are yet needed — facts that will enable us to see clearly without over-exercising the eye of faith.

The Post-embronic Development of Phaenoserphus viator Hal., a Parasite of the Larva of Pterostichus niger (Carabidae).

L. E. S. Eastham, M. A., M. Sc., Department of Zoology, Cambridge, England.

The great importance which has attached itself to the control of Insect pests by means of their natural parasites has given a big impetus to the study of parasitic insects in the past few years. In spite of the large amount of work done, however, there still remain appreciable gaps in our knowledge of parasitic forms and perhaps nowhere is our ignorance so marked as in the family *Proctotrypidae.* The economic importance of the members of this family is well recognised and though Ashmead (1902—3), Morley (1922), Kieffer (1914), and André (1879) have provided us us with sound systematic works, a search through the literature reveals a remarkable lack of information as to the rôle played by these insects in the economy of nature.

The early stages of members of the *Serphidae (Proctotrypidae* s. str.) have not yet been adequately described and except for a short account of *Paracodrus (Proctotrupes) apterogynus*, a parasite of the wireworm *Agriotes obscurus*, by Zolk (1924), information of a biological nature has to be gleaned from numerous short notes which refer to chance discoveries made while the authors concerned were in pursuance of other work.

Methods.

Infected larvae of *Pterostichus niger* were obtained from many districts in Warwickshire, Worcestershire, Staffordshire, Lancashire and Cambridgeshire. They were dissected in normal saline and parasites examined alive as far as possible, then fixed in Alcoholic Bouin or Carnoy's fixative for further reference.

Pterostichus larvae taken from a district where infection occurred were kept separately in boxes of soil and from such stock specimens were examined at fortnightly intervals till the time of emergence of the parasites.

The most important material was obtained from a small garden in Worcestershire, where 75 % of the beetle larvae were parasitised. Oviposition was never observed, but any uncertainty in the investigation is obviated by the examination of the specimens at short intervals through several seasons. In these periods complete agreement was seen to exist between the stages found month for month. It should also be mentioned that the observance of several moults, especially that from the first to second instars, clearly connects the polypod larva with its older apodous stage.

I would like to take this opportunity of thanking Mr. W. Leach of the Department of Botany, the University of Birmingham, for providing me with the first specimen of a parasitised carabid larva and Miss

E. Sikes, then of the Department of Zoology, Birmingham University, for supplying me with *Pterostichus* larvae on many occasions.

To Dr. J. Waterston of the British Museum, I am indebted for the identification of the adult parasites.

Distribution.

André (1879) reports *Phaenoserphus viator* Hal. as having a wide European distribution, it being found in Southern and Western Europe from the Crimea to France. Morley (1922) says it is common in woods in Ireland and England. Its occurrence in the counties of England already mentioned indicates that it may have as wide a distribution as its host and in view of the high percentage of parasitised larvae found at Alvechurch, Worcestershire, viz. 75%, it would appear that *Pterostichus niger*, by common consent a useful insect, is controlled to a considerable degree by this parasite.

Life History.

Phaenoserphus viator Hal. is a parasite of the Carabid larva *Pterostichus niger* and has an annual life history. Emergence of the adults occurs in August and September. First stage larvae are found in the haemocoel of the host in late September and onwards, and larval life continues till the beginning of the following August. As many as 45 parasitic larvae have been found in a single host, these being found in the haemocoel.

During the Winter months October to March the host hibernates and the contained parasites apparently accommodate themselves to this condition, undergoing little change.

In April the Carabid larvae again become active, but, if parasitised, quickly succomb to the effect of the contained larvae. They become sluggish, till in June they lie stretched out in holes in the soil absolutely motionless. Such infected larvae soon show signs of the contained parasites by the extension of all arthrodial membranes and by the raising of the skin into parallel ridges above the parasitic larvae. During the period just mentioned the parasites grow rapidly till in their mature larval state they measure about 4.6 mm. in length. In August the larvae emerge from between the sternal plates of the host in rows of three or four. The emergence is incomplete at this stage in so far as the last three or four abdominal segments of each parasitic larva remain imbedded in the now empty skin of the host larva. Then follows a prepupal instar of about 10 days duration, in the same position. A further moult on the part of the parasites discloses the pupae, white at first, but rapidly changing to a dark brown or black, the colour of the adult. The pupal stage lasts for about a fortnight and the flies which emerge remain round the hosts skin from which they came for about 24 hours, after which they spend their time searching the upper layers of the soil presumably for *Pterostichus* larvae.

In this life history the effect of parasite on the metamorphosis of the host is interesting for two reasons. In the first place, host larvae fail to pupate, and in the second, it should be noted that the biggest growth of the parasites takes place from the time that pupation of the host should have been effected, viz. May. Rapid growth of the parasites might be due to the host tissues having become more accessible to the digestive action of the saliv-

ary juices of the parasite owing to their already having undergone some changes concerned with metamorphosis. No such changes were observed and so long as the host organs were recognisable no phagocytosis was observed. The feeding of the parasites must alternatively be regarded as seasonal, reaching a maximum intensity in the months of May, June and July. Metamorphosis is clearly inhibited by the presence of the parasites. The effect produced may be one of starvation, as found by Singh-Pruthi 1925, on the metamorphosis of *Tenebrio molitor*. Roubaud (1922), in his excellent treatise on hibernation, would explain such a phenomenom as being due to a toxicity resulting from excretory matter produced by the parasites.

Larval Forms.

By employing the methods of Haviland (1920), viz. of observing important changes in the tracheal system throughout larval life, it is concluded that there are four instars. The first observed larva is caudate, polypod and tracheate. There are ten postcephalic segments and of these the last is the largest. This is a macro-segment from which four definite segments will ultimately develop. The development of these occur towards the end of the first larval stage. The head bears a pair of antennary papillae on its anterior surface. The mouth is ventral and is bounded anteriorly by a muscular labrum provided with six small chitinous teeth and posteriorly by a fleshy labium. The mandibles, which freely play transversely over the mouth, are pointed sickle-shaped organs bearing inner and outer condyles at the base for muscle attachments. The maxillae are represented by a pair of fleshy lobes with blunt apices. They lie immediately behind the mandibles. At the distal end of each are to be found three small papillae presumably sensory in function.

A chitinous ring giving support to the mouth-parts represents the rudiments of a head capsule. Posterior extensions from this ring give attachment to muscles passing back to the thoracic segments. These muscles play a prominent part in the movements of the head of the larvae.

Postcephalic segments are noteworthy for the fact that the second to the eighth bear each a pair of prolegs. Each proleg is a blunt cone attached ventro-laterally to the body and showing an incipient segmentation into three joints, the terminal one being the smallest and consisting of little more than a chitinous peg.

Towards the end of the winter segmentation takes place in the posterior region with the result that a fully segmented larva with thirteen postcephalic segments is formed. The terminal segment is clearly defined from the preceeding ones by the possession of a vertical fin-like projection of chitin both dorsally and ventrally. The anus is dorsal and the hypodermal end of the hind gut is connected with the exterior by a fine canal which perforates the dorsal part of the above mentioned chitinous fin. The caudate nature of the larva described is obviously different from that found in the *Ichneumonoidea*, where the last segment of the body is extended backwards beyond the anus to form a tail, e. g. in the Braconid *Mesochorus* Seurat (1899); or where a proctodaeal evagination produces a vesicle as in *Microgaster* Gatenby (1919). Incomplete segmentation of the abdomen resulting in a caudate larval form has been found in *Synopeas*

rhanis by Marchal (1906), in the Proctotrypid *Teleas* by Ayers (1914) and in the Proctotrypid *Rielia manticola* by Chophard (1922). It has also been found in the Chalcids *Schizaspidia tenuicornis* and *Psilogaster fusciventris* by Clausen (1923) and Parker (1924) respectively, and in the Cynipid *Eucoila keilini* by Keilin (1913). Its somewhat irregular occurrence in these different families makes the possibility of its being of any phylogenetic significance very remote. An explanation must rather be looked for in the conditions under which the egg develops. Of these conditions paucity of yolk seems to be the only one which has received consideration.

The larval forms peculiar to some parasitic Hymenoptera are regarded as embryonic, their having hatched precociously due to insufficient yolk in the egg; see Marchal (1906); Keilin & Pluvinel (1913). The particular form assumed by the first stage larva is then compared with one or other of the stages through which the typical insectembryo passes — Berlese (1913), viz. *protopod, polypod* or *oligopod*. Following precedent in this matter I have called the first stage larva of *Phaenoserphus viator* the *polypod* stage larva. But when we come to examine the larva more closely we find that only in the middle proleg-bearing region is it really comparable to Berlese's *polypod* stage. Posteriorly where segmentation is incomplete it is comparable to Berles's *protopod* stage, while anteriorly in mouth-part differentiation it is more nearly larval. It would appear obvious, therefore, that such a larval form differs from a normal insect larva not so much in its embryonic nature as in the abnormally greater degree of morphological diffentiation which is present in the head than in the tail. The morphological gradient (Child, 1915) from head to tail is steeper than in free living insect larvae.

Such a condition might easily be referable to the whole environment in which the embryo finds itself during development. Of the conditions making up this environment, paucity of yolk would only be one. Other conditions might be the nature of the host and position of the egg in the host, conditions which might reasonably be regarded as affecting the rate of oxygen and carbon dioxide exchange in the egg.

In the theory presented there is a tacit assumption that the prolegs are of ancestral significance. The alternative view to this, that they are as Keilin & Pluvinel (1913) assume, purely adaptive is difficult to hold in view of the fact that the prolegs appear to play no part in locomotion, any movement on part of the larva being effected by vigorous flexure of the body as a whole.

The three subsequent larval instars differ from the first in that they are apodous and tracheate. The second instar possesses mouthparts similar to the first. In the 3rd and 4th instars, however, the mouth, instead of being a transverse opening, is turned forwards at the sides. This is due to the increased prominence of the labrum in these stages. The mandibles are reduced to broad short pointed plates no longer able to function easily over the mouth and the maxillae are represented by two minute lobes, now a little removed from the mouth aperture. Feeding is now largely suctorial.

In the prepupal instar with the gradual evertion of imaginal structures the mouth again becomes more or less transverse with the result that the

mandibles and maxillae are carried backwards on to the ventral surface of the head.

The homology of the mouth-parts was determined by observing the changes which took place during the prepupal instar, the imaginal discs being always in contact with their larval counterparts.

The Pupa.

All the usual features of the exarate pupa of the Hymenoptera are presented. The female pupa is easily distinguished by its long ovipositor sheath, the external genitalia of the male being less conspicuous.

Those segments of the pupa which remain embedded in the skin of the host larva bear prominent hook-like lobes at the sides, pointing backwards. They probably serve as supports and organs of attachment for the pupa when in the attitude peculiar to this group of Proctotrypids.

Tracheal System of the Larva.

In the mature larva there are ten pairs of spiracles, one pair in all segments from the mesothorax to the eighth abdominal segment. From these, spiracular twigs pass inwards to a pair of lateral longitudinal trunks connected with one another by a prothoracic commissure which passes dorsal to the oesophagus. From the junctions of spiracular and longitudinal tracheae dorsal and ventral branches are given off which aerate the body wall and viscera, etc.

In the first stage larva which is atracheate, hypodermal thickenings are found in the second to the ninth postcephalic segments. These are the rudiments of spiracles.

In the second instar invaginations from these have developed, which in the thorax, have become connected by a solid rod of cells at each side, the rudiments of the longitudinal tracheae. In the third instar, longitudinal tracheae, still solid, have joined up the first six abdominal spiracles and in the 7th & 8th abdominal segments hypodermal thickenings rapidly developing into invaginations are present.

I have only found air in the tracheae in the last larval instar. At the beginning of this instar the main tracheal system is connected with other tissues of the body by means of elongated cells emanating from the ends of the tracheal branches. These cells are tracheole cells which later have developed within them fine intra-cellular lumina bounded by chitin which is formed by the cytoplasm of the cells. As far as my observations go it appears that only after the elongated cells grow out to meet other organs, does the tracheal system contain air.

This confirms Weismann's theory (1863), later confirmed by actual observation by Keilin (1924), viz. that there must occur a resorption of fluid in the ultimate points of the tracheal system to render possible the entrance of air into a tracheal system isolated from the atmosphere. As fluid is absorbed by way of the tracheole cells the column of fluid is ruptured and the space left is filled with gas which diffuses in from surrounding tissues.

Literature

1. André, E. 1879 — Species des Hymenoptères d'Europe et d'Algérie.
2. Ashmead, W. H. 1893 — Monograph of N. American *Proctotrypidae;* in Bull. U. S. Nat. Mus. 45.
3. Ayers, H. 1884 — On the development of Oecanthus niveus and its parasite *Teleas;* in Mem. Boston Soc. Nat. Hist. 3.
4. Berlese, A. 1913 — Interno ali metamorfosi degli Insetti. Redia, Vol. IX.
5. Child, J. 1915 — Individuality in Organisms. Chicago.
6. Chophard, L. 1922 — Les parasites de la Mante Religieuse; in Anal. Soc. Ent. France, Vol. 91.
7. Clausen, G. P. 1923 — The Biology of *Schizaspidia tenuicornis,* a Eucharid parasite of *Camponota;* in Ann. Ent. Soc. Amer. XVI.
8. Gatenby, I. B. 1919 — Notes on the Bionomics, Embryology, and Anatomy of certain Hymenoptera Parasitica, especially of *Microgaster connexus* Nees; in Journ. Linn. Soc. Zool. 33.
9. Haviland, M. D. 1920 — On the Bionomics and development of *Lygocerus cameroni* Kieffer, Proctotrypoidea - Ceraphronidae; in Quart. Journ. Micros. Sci. 65.
10. Keilin, D. et Pluvinel, E. 1913 — Sur la Biologie d'un Cynipide entomophage, *Encoila Keilini;* in Bull. Sci. France et Belge' 47.
11. Keilin, D. 1924 — On the appearance of gas in the tracheae of insects; in Proc. Camb. Phil. Soc. Biological Sciences, Vol. 1.
12. Kieffer, J. J., 1914 — Serphidae et Calliceratidae; in Das Tierreich 42.
13. Marchal, P. 1906 — Recherches sur la Biologie et le développement des Hyménoptères parasites. Les Platygasters; in Arch. Zool. Exp. 1906.
14. Morley, C. 1922 — A synopsis of British Proctotrypidae; (i) Subfamily Proctotrypinae; in The Entomologist, 1922.
15. Parker, H. L. 1924 — Recherches sur les formes postembryonaires de Chalcididae; in Ann. Soc. Ent. France.
16. Roubaud, E. 1922 — Etude sur le sommeil d'Hiver; in Bull. Biol. Fr. et Belg. LVI.
17. Singh-Pruthi, H, 1925 — Studies on Insect Metamorphosis. III. Influence of starvation; in Brit. Journ. Exp. Biol. III.
18. Seurat, L. G. 1899 — Contributions à l'étude des Hyménoptères entomophages; in Ann. Sci. Nat. Zool. 10.
19. Weismann, A. 1863 — Entwicklung der Dipteren im Ei; in Zeit. Wiss. Zool. Bd. XIII.
20. Zolk, K. 1924 — Zur Biologie von *Paracodrus apterogynus* Hal. (Esthonian, Summary in German); in Tartu alikooli Entomoloogia katsejaama teadaaded, Nr. 5.

Cotton Seed Disinfection as a Control for the Pink Bollworm, Pectinophora gossypiella Saund.

R. E. McDonald, Entomologist, Austin, Texas.

The pink bollworm was introduced into the part of Texas west of the Pecos River about ten years ago. That part of the State is too dry for agriculture except in isolated valleys, where irrigation is possible. In general these areas are rather widely separated one from another, no two of them being less than thirty miles apart. Except one, all the areas have considerable altitude, which causes winter temperatures much lower than is usual in cotton producing countries. In that portion of the territory, locally known as the "Big Bend", where the Rio Grande makes a considerable southward bend, the altitude of the agricultural section is much lower, with a considerably milder winter climate. During the several years of infestation of the pink bollworm in western Texas no appreciable damage has been done to the cotton crop, except in the Big Bend, and here the severe damage has been confined to a few fields.

The control secured in these areas is undoubtedly due to the disinfection of cotton seed as a continuous process of ginning, as required by Texas State Law. A large number of the pink bollworm larvae in cotton bolls in late season hibernate within cotton seed. Another considerable number spend the winter in the ground or in connection with rubbish on the surface or within old bolls in the field. Cold winters, pasturing of fields, and cleaning up preparatory to planting, cause a rather high mortality among the larvae hibernating outside, and the rate is undoubtedly increased in western Texas by the rigors of the winter. However, those larvae hibernating within stored cotton seed escape the cold and are ideally situated for a high percentage of survival.

Hence, we have considered it necessary to disinfect all infested cotton seed in endeavoring to control or eradicate this pest. This is best accomplished by means of heat. The germination of American cotton seed is not injured below a temperature of about 170°. Seed for milling purposes can stand a much higher temperature. The pink bollworm is destroyed when the mass of seed reaches a temperature of about 145 degrees Fahr. The process, however, is not quite so simple as it may seem. American cotton seeds come from the gin each surrounded by short fibre. This acts as a non-conductor to prevent heat from reaching the interior of the individual seed. Also it causes the seed to hang together, which interferes with the heating process. A machine to do the work satisfactorily must overcome these difficulties completely. The best place to heat all seed is at the ginning plant through which all seed must pass.

Fumigants can not be used satisfactorily in this connection without very radical changes in the ginning system now in general use. The producer brings his seed cotton to the gin. It is taken directly from the vehicle and the lint immediately separated from the seed. As soon as unloaded, he moves to the loading chute from which the seeds are dropped into the empty vehicle. The baled lint also is ready for delivery. The proper time for disinfection is the minute, or a little more, between the time the seeds leave the gin and the time they reach the loading chute; and the place is between these two points, which are usually separated by fifty feet or more. The time element can not be greatly extended without congestion of products and inconvenience to a large number of people. Hence, it will be seen that fumigants are wholly inadequate to meet these requirements. A modern battery of gins may turn out seed at the rate of eighty pounds per minute. Therefore, the maximum capacity of the disinfecting machine should be at least this. The apparatus which gives us best service is one that stirs the seeds continuously and moves them forward over metal heated to a temperature of about 300° F for such a distance as will cause the seeds to attain a temperature of 145° F or more. Hot air is not satisfactory as a heating medium. Its conductivity and specific heat are too low. Metal is also of low specific heat; but its conductivity is so good that this is offset. Furthermore, the metal surface of our machines consists of steam pipes. In this case, although the metal itself does not hold much heat, the steam inside instantly replaces that taken out.

The heating machine now in most general use consists of an ordinary screw conveyor, around the lower part of which are placed about twenty onehalf inch steam pipes parallel to it and almost, but not quite, in contact with it. The whole is inclosed in an insulated box. The length is forty feet or more, according to size of conveyor and revolutions per minute. It is necessary in this machine to introduce a small amount of moisture into the seed at the beginning in order partially to break down this insulation. This is done by directing live steam onto the seed or by dripping hot water onto the steam pipes, where it is vaporized. Unless the seeds are slightly dampened, the machine must be about twice as long as was mentioned. The machine as used disinfects the seed completely in about sixty seconds. It will be seen, therefore, that this machine is constructed by merely building around the conveyor already in use the proper heating equipment. The steam pressure is kept fairly uniform, the higher the better; but the machine can be made to function on rather low boiler pressure when the latter is kept uniform. Since the heated steam pipes with which the seeds come in contact have a rather constant temperature, regulation is largely accomplished by the amount of hot water or live steam introduced in the beginning.

In order to know at all times what temperature is being imparted to the seed, a recording thermometer is so placed that all seeds pass over the sensitive element immediately after leaving the machine.

The cost of this process is very small. Where ginning plants are already equipped with steam boilers, the cost probably does not exceed twenty cents per ton of seed.

Those interested in cotton culture in the infested areas are convinced that this process of disinfection is responsible for the freedom from injury

from the pink bollworm and do not desire to discontinue it. We think that the process has had much to do with the prevention of the spread of the pest by freeing so quickly the large volume of seed from all or practically all living larvae and by keeping down the pink bollworm population. We are not convinced, however, that, where climatic conditions are so favorable as to allow a large carry-over outside, damage can so easily be prevented. The fact that in the milder climate of the Big Bend area considerable damage has been done to the crop, indicates that under such climatic conditions seed disinfection alone can not be depended upon for complete control.

In those areas under discussion, except the Big Bend, winter temperatures of 10° F are not unusual. In the Big Bend 20° F is regarded as rather low.

The Influence which Geographical Distribution has had in the Production of the Insect Fauna of North America.

Dr. Edwin C. Van Dyke,
University of California, Berkeley, California.

We have long known that the insect fauna of North America is possessed of certain peculiarities which are eminently its own, also that it has many features which it shares with other parts of the world. Many reasons are assigned for this. One of these and perhaps the dominant one is that due to geographical distribution. This, taken in connection with the geological history of the continent and its climate, for they cannot be well dissociated, has most certainly had much to do not only with the distribution of the species, but with the moulding of the same into their modern form. The present fauna of the country is not a uniform one, as all entomologists know. The species, genera, and even dominant families are different in the various parts of the continent. As a result of this, those who have given most attention to the subject have divided up the country into various regions according to the faunal and ecological peculiarities, and have applied distinctive names to these, the so-called zoo-geographical faunal regions. This has greatly aided the study of the subject.

In the present paper, I will discuss the subject from this standpoint, taking up the various faunal regions in succession. Inasmuch as these are more or less well known to most workers, I will not attempt to define them in more than a general way. The peculiarities, make-up and outside relations will receive more attention, and the climate, past and present, and such other factors as may have influenced the migration, settlement and modification of the insects within their present confines, will also be dwelt upon. I will draw my data to a great extent from the Coleoptera, seeing that most of my studies have had to do with that great order, also because I believe that it is the most reliable of all groups of insects for that purpose and for many reasons.

Our most northern faunal region is the Arctic, located to a very great extent north of the arctic circle or beyond the line of normal tree growth and extending south here and there along the summits of our higher ranges. The fauna *) of this region is a limited one, containing a few of the primitive Thysanura and Collembola, a small number of Plecoptera, Trichoptera, Orthoptera and Hemiptera, and a somewhat more numerous

---

*) Report of the Canadian Arctic Expedition, 1913—18, Vol. III, Insects, Ottawa, 1919—23.

Poppius, B., Coleopteren des Arktischen Gebiets, Fauna Arctica, Vol. 5, Pt. 1, pp. 291—447, 1910.

representation in the orders Diptera, Lepidoptera, Hymenoptera and Coleoptera. The Odonata, Formicoidea, and other groups well represented farther south are entirely absent. In the Coleoptera, the predaceous forms dominate, and such families as the *Carabidae*, *Dytiscidae* and *Staphylinidae* are represented by numerous species. The phytophagous forms, such as the *Chrysomelidae* and *Rhynchophora*, have contributed but few genera and species with many of these terrestrial. In the former family are a few representatives of *Chrysomela*, *Lina*, *Phytodecta* and *Entomoscelis*, while in the latter are to be found a number of *Lepyrus*, *Lophalophus*, *Lepidophorus*, *Dorytomus* and *Orchestes*. The moss feeding *Byrrhidae* are also quite characteristic of these northern lands. Among the *Carabidae* are to be found certain genera and species which throw much light upon the origin and distribution of the fauna. In the typical genus *Carabus* there are several truly arctic species, such as *truncaticollis* Esch. and *vietinghovi* Adams. The first is to be found in this country on the Pribilof Islands, near Mt. McKinley and Nome. In the Old World its place is taken by *Carabus polaris* Popp., a form which extends along the northern shore of Siberia from near Behring Sea to the Ural Mountains. This species is so closely related to *truncaticollis* that it was originally considered as such and has in fact been separated on quite trivial grounds. *Carabus vietinghovi* Adams, which is found about Nome as well as in parts of the Hudson Bay region, also occurs in various parts of eastern Siberia, chiefly about Lake Baikal. The fact that our two species are quite isolated in America as well as somewhat restricted in distribution, whereas their Old World relatives have many near associates and are much more widely scattered, would seem to indicate that the latter country was their original home and that the American species were comparatively recent immigrants. In the genus *Nebria*, we also have a number of species which are confined to the same territory. One of the most interesting of these is *Nebria bifaria* Mann., a species resident on the Pribilof Islands and found on the mainland from Nome and the base of the Alaska Peninsula to the Mackenzie delta, also accredited to Kamtschatka. A close relative, *Nebria nivalis* Payk., takes is place in the extreme north of Europe and Siberia. These two species undoubtedly have a common origin and can even now be separated only by experts, north-eastern Asia would seem to be the original home of both. In the subgenus *Cryobius* *) of the genus *Pterostichus*, we have a group of small *Carabidae* which is confined to the northern parts of both northern hemispheres, with a few species in the extreme north of Europe, many in northern Siberia and perhaps an equal number in arctic America. No species are supposedly common to the two continents, though each continent possesses many which are hardly separable from a similar series in the opposite. The species are very plastic so that their separation is difficult and their status but a matter of opinion. The distribution indicates a common origin somewhere near Behring Strait, probably on the Asiatic side and their great instability, the fact, that they have not been long within their present territory. Other carabid genera having a somewhat similar distribution and history are *Elaphrus*, *Diachila*, *Notiophilus*,

*) Zur Kenntnis der Pterostichen-Untergattung *Cryobius* Chaud., by B. Poppius, Acta Societatis pro Fauna et Flora Fennica, Vol. 28, No. 5, pp. 1—280, and map.

Loricera, Asaphidion and portions of *Bembidion.* The same thing holds true with many Dytiscidae and Staphylinidae. In fact a careful examination of the arctic fauna of America as a whole shows what is clearly indicated by the specific cases given above, that, though it possesses many distinct species, it is yet very closely related to the arctic fauna of Siberia. It also shows that these divergent species have separated within quite recent geological times and that because of the dominance of the species of most of the genera in northern Asia and their wider distribution there, the presumption is that this continent is the main center of distribution for the most of them. In fact, in regard to one of the genera, *Asaphidion,* a most interesting piece of information has been unearthed by H. E. Andrewes*), which is that whereas these species are now limited in numbers in northern Europe, north-eastern Asia and North America, there being but three in the far north of the latter continent, they are moderately common on the high Himalayan region. The present arctic fauna, I am inclined to believe, is not a recently evolved one, that is as regards its fundamental elements, but a rather old one which has been developed to a great extent on the highlands of mid-Asia and has spread to its present territory probably during Pleistocene times. The species in these frigid regions have been affected or modified in various ways, such as by the reduction of their wings, and the consequent modification of their bodies, the prevention of a full expansion of their exoskeletons producing a shrunken appearance or greater wrinkling of their surface, and a reduction in the amount of pigment deposition. The metamorphosis is also often greatly retarded and prolonged as has been shown by the biological study of certain Scandinavian Lepidoptera. Many genera like *Carabus* and *Pterostichus* have long been wingless, but others like *Nebria, Bembidion* and *Chrysomela* have the majority of their species fully winged. In the arctic regions and on the high mountains as well as along the sea-coasts, where there is to a certain degree a condition of climatic stability, although one of rigor in places, many of these species are gradually losing the use of their wings, so that we have today species with all degrees of alar atrophy, many with a great degree of variability in this regard even within the limits of the species. This is one of the reasons why I believe that this fauna is comparatively recent within its present territory. The wrinkling and shrinkage of the chitinous skeleton which is shown by the very much roughened or pitted surface as well as individual distortion is very common among our arctic *Carabidae* and *Dysticidae,* so common in fact that in a large series of many of the species one will see a great degree of variation not only as to sculpturing, but also as to size and outline. This has, of course, confused many systematists working with limited series and led to the unnecessary multiplication of specific names. In regard to the reduction of pigmentation, this is shown in the production of rufinism, very common in many species of arctic Coleoptera, and in the great degree of color variation produced among the metallic species, where the range may be from almost black through bronze to a most brilliant green. This must not, however, be confused with certain color changes which are due

*) The Oriental Species of the Genus Asaphidion, Notes on Oriental Carabidae vii., in Entom. Month. Mag., Vol., 61, pp. 49—58.

to abrasion, the wearing away of the microscopical sculpturings which have much to do with the production through refraction of much of the brilliancy of many *Carabidae*, commonly observed in many species of the subgenus *Cryobius* of *Pterostichus*. All of these conditions are, no doubt, much influenced by cold and the amount of light.

To the south of the Arctic in North America is found a broad belt of more or less barren ground which has been called the Hudsonian faunal region. Here tree growth is more or less in evidence, for though the winters are severe, the summer days are long and hot, with the result that the vegetation is often rank and abundant. Many of the insects which live in the Arctic region are to be found here, but the fauna as a whole is much richer and more varied, containing many of the typical forest Coleoptera, such as *Cerambycidae*, *Pythidae*, *Melandryidae*, and *Scolytidae*, with quite a sprinkling of *Scarabaeidae* and *Elateridae*. *Diptera* and *Hymenoptera* are far more abundant and many species of butterflies are also to be found, such as *Parnassius*, *Eurymus*, *Oeneis*, and *Erebia*. The Hudsonian is, however, like the Arctic, a decidedly boreal region and shares with it many of its peculiarities, not only the climatic, but the floral and faunal as well. The insect life is not only more abundant as a whole, but there are more genera and species to be found here which also occur in the Old World. At the same time there are to be found many more species allied to those in Europe and Asia, which are more divergent from their European relatives than are those which dwell in the regions farther north. The general relationship between the Hudsonian insect fauna and its counterpart in Europe and Asia is the same as that observed for the two arctic faunas. The Hudsonian is, however, no doubt older than the Arctic. Indications are that much of it established itself before the Pleistocene or at least earlier than did the Arctic. Much of it also probably originated in the highlands of middle or northern Asia. The genus *Parnassius* among the butterflies well illustrates this. Many species of this genus are to be found in the Pamirs and other mountains of mid-Asia, while but three species have penetrated into Europe and but a limited number into this country. Many Hudsonian species of insects are also much more widely distributed, having travelled so extensively during the Great Ice Age that with its subsidence they were left stranded as relicts on the mountains of New England and New York as well as far south along the Rocky Mountains and Cascades and Sierra Nevada. The less rigorous conditions faced are to be noted in the general better developments of the specimens and their greater constancy both of form and color.

Bounding the Hudsonian region on the south is the Canadian. This extends as a broad belt across Canada and the northern states of the United States from the Atlantic Ocean to the Rocky Mountains, thence in a narrow tongue south along the higher levels of the latter and the more eastern slopes of the Cascades and Sierra Nevada mountains. A small portion of its fauna is also to be found established in the more elevated parts of the Allegheny mountains. The Canadian region is in general heavily timbered, chiefly with coniferous trees, especially with spruces and true firs, *Abies*, though some pines like the five leaved species and the lodgepoles, *Pinus murrayana* B a l f., are equally characteristic. It is also a region of abundant summer rains and much water in the form of lakes,

rivers and swamps, and as a consequence has a rich aquatic and semi-aquatic flora. The insect fauna is as a result quite rich and characteristic, with a large number of the typical temperate forest forms as well as great numbers of water dwellers. The relationship of the fauna as a whole as shown by the possession of common genera is fairly close to that of the similar coniferous forest areas of Europe and northern Asia. It is considerably richer in many regards than Europe and in some respects also richer than its companion fauna in Asia, in other respects much poorer. The faunas were evidently closely linked together during the late Tertiary times. Even now there are to be found many species which are common to all, such as the spruce plant louse, *Chermes abietis* Kalt., numerous Lepidoptera and Hymenoptera and many Coleoptera, as can be seen by consulting Hamilton's Catalogue of Coleoptera *) common to North America, northern Asia and Europe. An even greater number of species is also to be found which is but slightly divergent. The peculiarities of the fauna especially in contrast to that of similar origin in the Old World are more as regards the proportionate make-up rather than as regards the peculiarities of the species themselves. The majority of the species of the Canadian region which have close relatives in the Old World have diverged mainly as a result of time and isolation. I cannot see that there have been any special local influences at work different from those found abroad or that the species have diverged to a greater or less degree from their common stock than have their relatives in the Eastern Hemisphere. As regards the proportionate composition of the fauna, the case is different. The aquatic genus *Donacia* of the *Chrysomelidae* is especially well developed in the Canadian region, and the genus *Pissodes* among the *Curculionidae*, and *Dendroctonus* among the *Scolytidae* have the dominant number of species in the New World. In *Carabus* the reverse holds true, for this is especially characteristic of the Palaearctic and has but few representatives in this country. These cases indicate that the centers of distribution were different, that for *Carabus* undoubtedly in the Old World, and probably those of the others, especially *Dendroctonus*, on this continent. Opportunities for specific expansion or differentation may also have been better here for both *Donacia* and *Pissodes*, particularly the latter, because of the very rich and diversified coniferous flora. The Arctic, Hudsonian and Canadian are regions whose faunas not only merge gradually into each other, but they are also rather closely linked up with similar faunas in the Eastern Hemisphere and as has been indicated above by the very slight degree of divergence of the species, have been isolated from each other for but a short time, geologically speaking.

In the eastern part of the United States and south of the Canadian region, there is to be found an extensive territory wherein is found a fauna which is often spoken of as the Alleghenian. This is most characteristic in the Appalachian mountains, but extends more or less throughout the area in which grow the hardwoods or broad leaved trees. By many the name has been somewhat limited, restricted to the fauna of the more mountainous regions, the more lowland fauna being called the Carolinian. The faunas are, however, closely related and having a common origin, are best treated

---

*) Trans. Amer. Entom. Soc., Vol. 16, pp. 88—162, 1889.

as a unit as was done by Wallace.*) On the higher levels of the Appalachians there is to be found some vestige of the Canadian fauna as was indicated previously. The greater part of the mountains are clothed either with pine forests or a mixed growth of broad leaved trees, and this holds true with much of the lowlands. Here the winters are only moderately severe and the summers warm and with abundant rains. The insect fauna is rich and varied and contains many of the most characteristic species of North America. Among the Coleoptera are to be noted many genera, such as the more typical subgenera of *Scaphinotus, Sphaeroderus, Pasimachus, Evarthrus, Loxandrus* and *Dicaelus* from among the *Carabidae;* the bulk of *Melanactes* among the *Elateridae; Typocerus, Dorcaschema* and *Goes* in the *Cerambycidae; Macrobasis* and *Pomphopoea* in the *Meloidae;* as well as many genera scattered among the *Rhynchophora.* Many of the most characteristic genera are, however, the small and monotypical ones which are to be found in most families. In addition to these local genera, this region possesses representatives of many which are not met with elsewhere in North America, but appear again in either Europe or northeastern Asia, the so-called Japano-Manchurian region. Such are *Panagaeus, Myas, Anophthalmus, Rembus, Olisthopus, Atranus, Lachnocrepis* and *Oodes* in the *Carabidae,* and *Oxyporus, Lucanus, Dorcus, Phileurus* and *Osmoderma* in other families. Besides these there are, of course, many genera which have intruded from the south, offshoots of the Austro-Riparian, though really derivatives of the true South American or Neotropical fauna, and in the west, many which have come from the Sonoran, the arid fauna of northern Mexico and our own southwest. These will be discussed later. An analysis of the Alleghenian fauna as a whole shows that it had a common origin with the temperate faunas of Europe and Asia, that it most likely was not only continuous with the others, but continuous for a long period and as shown by the related flora, situated much farther to the north during Tertiary times. Toward the end of the Tertiary, it gradually drifted south, so that by the late Pleistocene it was well established in much of the territory that it now occupies. Later with the coming on of a cooler climate and the development or expansion of the more boreal faunas, it was definitely cut off from its association with the faunas of the Old World, and during the height of the Pleistocene or Great Ice Age, was rapidly crowded south. Much of the more specialized or less mobile part was then no doubt exterminated. The portions which remained were concentrated in the southern parts of the Appalachian mountains or about the Ozark highlands. In these regions the fauna is found at the present time in its greatest purity and richness and here and nowhere else are to be found many of the highly specialized forms. With the retreat of the great ice sheets and the moderation of the climate, the fauna gradually advanced northward and towards the west, small elements getting as far to the northwest as eastern Oregon and Idaho as is shown by *Trichius,* and far to the southwest as is shown by numbers of species of *Scaphinotus* in the mountains of Arizona. Being not only widely separated geographically, but absolutely cut off during a long geological period, this fauna had an

*) The Geographical Distribution of Animals.

opportunity to develop to a great extent along its own lines. It no doubt also had the good fortune to receive and preserve many genera which were eliminated elsewhere. *Pasimachus, Evarthrus* and *Dicaelus* are such. An interesting fact with regard to these old endemic genera is that when they once started to expand after being suppressed, they apparently lost their stability to a great extent. Thus we have as a result a rather rapid breaking up of many of the species, or modification of the same, into a great number of closely related species, subspecies and forms. This has occurred not only near their extremes of distribution where they would be in new territory and forced to adapt themselves to new environments, but near their main centers, where supposedly environmental conditions would be at the optimum as regards conditions of stability. This is shown very markedly in the subgenus *Irichora* of *Scaphinotus*, in *Evarthrus* and its allies, and in *Loxandrus*. The Alleghenian fauna is also in many regards in close agreement with the flora in being more closely related to that of the Japano-Manchurian than with the temperate fauna of Europe or northwestern America as was long ago brought out by Dr. Asa Gray.*) Such genera as *Lachnocrepis* limited to the two faunas, as well as the possession by both of great numbers of the elaterid genus *Melanotus* and the presence of the large genus *Holotrichia* in the Japano-Manchurian and the hardly separable *Phyllophaga (Lachnosterna)* with a dominance of its species in the Alleghenies, clearly indicate that this is so. The Alleghenian fauna is thus shown to have a marked individuality, for it possesses many genera which are strictly limited to itself. At the same time it also shows its relationship and common origin with the other northern temperate faunas by having most of its genera in common and many with one or the other of these regions. Time and isolation have, of course, modified its species and the vicissitudes of travel and changing climates left its mark on the fauna, but the general appearance of the insects themselves is not much different from what you would find in either Europe or northeastern Asia.

Related to the Alleghenian fauna and like it derived from a common Holarctic fauna, is one situated on the other side of the continent. This, I have been pleased to speak of as the Vancouveran**) and the territory which it occupies as the Vancouveran faunal region. This extends from the Aleutian Islands and southeastern Alaska, south along the Pacific Coast and west of the Selkirk and Cascade mountains, through western British Columbia, Washington and Oregon and in a narrower belt south along the immediate coast of California to just below Monterey. In northern California part of this becomes somewhat modified and as such extends south along the western flanks of the Sierra Nevada mountains. A small part of the Vancouveran also invades the Rocky Mountain region.

---

*) The Flora of Japan, Scientific Papers of Asa Gray, Houghton-Mifflin and Sons, 1889, Vol. II, pp. 125—141.

Extract from Memoirs on the Botany of Japan in its Relations to that of North America, and of Other Parts of the North Temperate Zone, Memoirs Amer. Acad. Arts and Sci., n. s., Vol. VI, 1859.

**) The Distribution of Insects in Western North America, by Edwin C. Van Dyke, Ann. Entom. Soc. Amer., Vol. 12, No. 1, pp. 1—12, 1919.

Certain Peculiarities of the coleopterous Fauna of the Pacific Northwest, by Edwin C. Van Dyke, ibid., Vol. 19, No. 1, pp. 1—12, 1926.

This is a region of mild though wet winters and of temperate summers. The forests are mainly coniferous and in the more northern part very dense and sombre. The fauna is a moderately rich one as to species, but not as to specimens, and like the Alleghenian, very distinct and possessing some of the most peculiar genera which we have in North America. As compared with the other three temperate faunas of similar standing, that of temperate Europe and Siberia, the Japano-Manchurian and the Alleghenian, it appears as the most peculiar. This is especially well shown in the Coleoptera by its paucity in such phytophagous families as the *Chrysomelidae*, *Scarabaeidae* and *Curculionidae*, families that are rather generously represented in all of the other faunas. It is the only one that lacks *Attelabidae*. It possesses in common with these a goodly number of *Carabidae*, *Staphylinidae*, *Elateridae* and a fair representation of the temperate forest insects. Its distinctive Coleoptera are such genera as *Omus* of the *Cicindelidae*, various subgenera of *Scaphinotus*, *Metrius*, *Promecognathus*, *Zacotus* and the bulk of the subgenus *Hypherpes* Chaud. of *Pterostichus* among the *Carabidae;* a dominance of the genus *Hetaerius* of the *Histeridae;* a number of peculiar and small genera among the *Elateridae*, *Chrysomelidae* and *Cerambycidae*, and many characteristic genera within the subfamily *Otiorhynchinae* of the *Curculionidae*. Other peculiarities are shown by its possessing characteristic genera in common with one or more of the other faunas but not with all. For instance, it shares alone with the faunas of the Old World *Trachypachys*, *Cychrus*, and *Leistus* among the *Carabidae; Brychius* of the *Haliplidae; Sphaerites; Trigonurus* of the *Staphylinidae; Pteroloma* of the *Silphidae; Nemosoma* of the *Ostomidae; Dascillus* of the *Dascillidae; Malachius* of the *Melyridae; Hedobia* of the *Ptinidae; Sinodendron* of the *Lucanidae; Oniticellus* of the *Scarabaeidae; Rosalia*, *Nothorhina* and *Ergates* in the *Cerambycidae;* and *Timarcha* in the *Chrysomelidae*. The neuropterous family *Rhaphidiidae* also closely shares this relationship. With the European fauna it shares alone but little. The genus *Sinodendron* is common to the two. With the Japano-Manchurian fauna, including that of the mountains of western China, it, however, has quite a number of genera in common, such as *Opisthius*, *Amphizoa*, a dominance in the family *Cephaloidae* and the genus *Pedilus* of the *Pedilidae*, there being but a few species of each of these latter in eastern North America and none in Europe. The Vancouveran also shows a very interesting relationship with the Japano-Manchurian and the Alleghenian in the common possession of a number of peculiar genera, such as *Ischalia* in the *Pyrochroidae*, *Dasycerus* of the *Lathridiidae*, *Encyclops* in the *Cerambycidae*, besides many closely related *Elateridae*, especially in the genus *Ludius*, and certain species of *Leptura*. The Vancouveran fauna as a whole has been modified since its isolation much in the same manner as has the Alleghenian. It did not suffer to such an extent from the rigours of the Pleistocene as did the other, though it was forced southwards, extending at one time in a connected form as far south as northern Lower California. This was no doubt during the period of greatest cold. At no time were the lowlands completely blanketed with ice, as was the case in the northern part of eastern North America. The high mountains merely carried a heavier covering of snow and the glaciers were larger and more numerous. In the north, many of these reached

the coast, but in the Sierra Nevada mountains none extended below the foothills. With the moderation of climate, the fauna was able to extend itself somewhat in the north and higher up on the ranges, portions of the mountain fauna becoming in time quite isolated as they retreated to the higher mountains. In the north the indications are that much of the fauna remained throughout the Pleistocene, isolated at times in little islands between the great glaciers, but at no time entirely obliterated. In the southern part of California, with the approach of warmer conditions and greater aridity, the insects of the Vancouveran diminished rapidly in numbers, especially in the lowlands. Many were able to hold their own by retreating to higher levels, the more shaded canons or watercourses, or by adapting their main activities to the wetter and cooler part of the year, aestivating during the summer or burrowing deep down into the ground as warm weather approached. The warmer climate allowed the more southern and sun loving faunas to advance, so that these in time populated the lowlands and sunny slopes of the hills and mountains, with the result that what remains of the true Vancouveran fauna south of Monterey is not now continuous but more or less broken up into little faunal islands. In the dense and sombre forests of the north the fauna has become slightly modified in several ways, but chiefly as regards color and size of specimens. Species which in Alaska or British Columbia are normally somewhat metallic or reddish in color become darker or more heavily pigmented in Washington and south and generally increase in size. Species which are yellowish or brownish away from the coast or farther north, also often become black within the more humid coastal area. Because of the dampness, many normally terrestrial forms also often forsake the ground and establish themselves in old logs or even in the dense underbrush. This is, of course, not unique, for the same thing is equally common in the very wet areas of the Alleghenian as well as elsewhere. As a result of occupying the same territory continuously and for a long period with but slight climatic changes, the pure Vancouveran fauna has been able to preserve many of its delicate or more highly specialized species. Many of its species also often have a great latitudinal range, in some cases from Alaska to southern California. Those which formerly had a greater continuous southern range also show, as a result of the breaking of this continuity, a tendency to split up into many divergent races and species, with the result that we have today many genera with numerous closely related species, subspecies and races.

Of southern faunal areas, we have two and two which are quite dissimilar. The first which I will mention is that which occupies much of the area near the Gulf of Mexico and is generally called the Austro-Riparian region. The fauna is but an extension northward along the lowlands near the Gulf of Mexico of the tropical fauna from Central and South America and as a result is dominantly Neotropical as regards its make-up. This has introduced into the United States many southern forms, such as hosts of genera like *Megacephala (Tetracha)* in the *Cicindelidae; Ardistomis, Casnonia, Galerita, Ega* and *Helluomorpha* in the *Carabidae; Copelatus* in the *Dytiscidae; Chalcolepidius, Hemirhipis, Dicrepidius* and *Ischiodontus* in the *Elateridae;* as well as many phytophagous genera, such as *Pelidnota, Dynastes* and *Gymnetis* in the *Scarabaeidae; Diabrotica* and

Leptinotarsa in the *Chrysomelidae; Stenodontes* in the *Cerambycidae;* and a great many among the *Rhynchophora.* Most of these Neotropical elements have not remained strictly confined to the Austro-Riparian, but have intruded to a great extent into adjacent regions, so that we find today many representatives not only in the Alleghenian, especially that portion called the Carolinian, but also in the more western Sonoran, of which we will speak later, and even into the Canadian. To see how wide spread some of them have become, one has only to note the distribution of *Diabrotica,**) *Leptinotarsa, Zygogramma* and *Calligraphica* in North America. The species in the United States are as a rule quite different from those found farther south, showing that portions of this fauna have long been established within our territory. No fundamental modifications are to be observed in these, however, such as might be brought about by a new environment. In southern Florida a limited fauna with West Indian affiliations has established itself. Though slightly different from that just discussed, it is yet of Neotropical origin and should be considered with the preceding.

In northwestern Mexico and the southwestern part of the United States is to be found a rather arid region wherein is located a fauna which, though of southern origin, has become so greatly modified that it is today one of the most peculiar and distinct to be found on this continent. This is called the Sonoran. It is a fauna which contains elements that are characteristic of the tropics, thus showing its ancestral origin, in this case the Neotropical, but it, of course, lacks the richness of the latter as regards the forms which require much moisture or succulent vegetation such as the *Chrysomelidae.* The species of this fauna are now eminently adapted to their environment. Their period of emergence or appearance in greatest numbers and activity is attuned to the wet months of the year, the late summer in Arizona and Sonora, the winter and early spring in California. A goodly proportion are also nocturnal, burrowing down into the sand during the day to escape the intense heat which occurs at the surface of the soil. Many are also much modified as to color being either black or very sombre in appearance, as is the case with many terrestrial nocturnal Coleoptera, especially noticeable in the *Tenebrionidae,* or quite light in color to enable them to harmonize with the desert sands and gray herbage. Many are very hairy or densely scaly, to enable them either to shed the sand or to be insulated against the excesses of temperature. Great numbers, especially among the Coleoptera, have also lost their wings or at least the use of them, this being due no doubt, as I stated before in reference to apterous arctic forms, to their dwelling in an environment where conditions were more or less uniform over great extents of territory. In this connection should be mentioned the interesting fact that in many species the females alone are wingless, the males being amply provided with wings, a condition which, as I have stated in an earlier paper**), is probably due not only to the above condition, but also to the need of the females to produce an increased number of eggs, thus in time becom-

---

*) The Diffusion of Insects in North America, by F. M. Webster, Psyche, Vol. X, pp. 47—58, 1903.

**) The Secondary Sexual Characters of Coleoptera, Proc. Pac. Coast Ent. Soc. Vol. 2, No 5, pp. 75—84, 1927.

ing too heavy to use their wings and so gradually losing them or at least the use of them. We have many cases where this is to be noted among the Coleoptera of this region, as in *Pleocoma* in the *Scarabaeidae;* in *Aplastus, Octinodes* and *Euthysanius* in the *Elateridae;* and *Gynaecomeloe* in the *Meloidae;* not to mention *Zarhipis* and *Phengodes* in the *Cantharidae (Lampyridae),* where the females have degenerated to such an extent that they retain their larval appearance. This condition is also to be found in many desert *Blattidae* and *Locustidae (Acrididae)* as well as in other families and orders. The most characteristic Coleoptera of this arid region are the *Tenebrionidae, Alleculidae, Meloidae, Buprestidae* and *Otiorhynchinae.* In the Diptera the *Bombylidae* and *Asilidae* are equally evident, and in the Hymenoptera such families as the *Bembicidae, Psammochoridae, Mutillidae* and *Scoliidae.* The fauna as a whole is a rich one, but the richness is not always evident to the casual observer, for much of it is nocturnal and much limited as regards the appearance of the adults to a very short period. As a result of my studies, I have come to the conclusion that this fauna is composed of two quite distinct portions: the true Sonoran which has originated in the highlands and arid lands of northwestern Mexico and the adjacent portions of Texas, New Mexico and Arizona; and the Californian as I have called it in a previous paper,*) a fauna which is now restricted to the western part of Lower California and dominates the southern portion of Upper California west of the Sierra Nevada mountains. This latter fauna has not been derived from the more typical Sonoran fauna, but has either been evolved within its own territory or more likely has worked north in early geological times from the lands to the south or Lower California. Many of its genera show a close relationship to those now found in northern Chile and Peru. The characteristics of this fauna are in general the same as those of the more typical Sonoran, showing that its members have been influenced by the same environmental factors, though its genera and species are quite different. Many of the elements of this fauna have, of course, worked their way into Sonoran territory, as have many of those of the Sonoran into Californian territory.

It will thus be seen that we have the insect fauna of North America about equally divided as regards its origin between the Holarctic and the Neotropical. The more northern faunas of the continent show close relationship to similar faunas in the Old World and have been modified in general along the same lines by a similar rigorous environment, though isolation has, of course, allowed specialization to take place along with these modifications. South of the more boreal faunas are to be found two of the most characteristic faunas of North America. Though these are relicts of the same ancient Holarctic fauna, they are derived from the more temperate and older portion and are as a result closer to the ancestral stock and richer than any of the preceding. They have not been subjected to such rigorous conditions, yet have been much modified through long isolation, new environmental conditions and enforced migrations. These are the Alleghenian in eastern North America and the Vancouveran in north-

*) The Secondary Sexual Characters of Coleoptera, Proc. Pac. Coast Ent. Soc. Vol. 2, No. 5, pp. 75—84. 1927.

western North America. Of the faunas which show Neotropic relationships, that which occupies southern Mexico and extends along the Gulf of Mexico into our southern states, the so-called Austro-Riparian, as well as that related West Indian element in southern Florida, is but a slightly modified form of the typical Neotropical which is to be found in Central and South America. The Sonoran, however, is a fauna which, though probably derived from the Neotropical, has occupied for such a long time a territory where conditions are so very different from those of the humid tropics where the typical Neotropical is to be found, that it has become much modified, so much in fact that it stands out as one of the most distinctive of our continent. This with the Alleghenian and Vancouveran furnishes the great proportion of the characteristic genera and species which we have. North America, though now quite isolated, has in the past had a good connection with northeastern Asia and as a result shows in its northern part an insect fauna quite similar to that now found in the northern portion of the Old World. It still has a slight connection with South America and in times past has had a much greater one and this is to be shown by the rather definite Neotropical element which we possess as well as by the very large Sonoran fauna which, though greatly modified, I consider as having been derived from the same. Much of what we have is still quite similar to that found in the continents from which we have derived much of our basic stock, but a large portion of our fauna is quite different, showing that time, isolation and new environments have left their mark.

The Codling Moth in the Pacific Northwest: Status of present Spray Practices and Prospects for Improvements in Control Measures.

E. J. Newcomer, Senior Entomologist,
Bureau of Entomology, U. S. Department of Agriculture, Washington, D. C.

The commercial apple industry of the Pacific Northwest began only about 30 or 35 years ago. At that time control of the codling moth by spraying had become established in America, but was being adopted rather slowly. As a result, the codling moth soon became widespread in the Pacific Northwest. That it rapidly became a pest of major importance is evidenced by the fact that the United States Bureau of Entomology began its first special investigation of the codling moth in Southern Idaho in 1900. Even at this early date, losses ranged from 40 to 60% of the crop, and several applications of spray were advocated.

Following this, Melander*) began investigating the codling moth in Washington, and recommended a single, thorough, calyx application, using a driving spray, as the best means of control. For a time there was a controversy between the East and the West over the relative merits of calyx and cover applications, and driving and mist-like sprays. Spraying became an established custom with the fruit growers, but it gradually became evident, with the development of new orchards and the increasing size of the trees, that, in general, a single application was not sufficient, although it was adequate in some sections of the Northwest as late as 1914.

Spraying machinery had improved, with the increasing demand, and after 1916 the spray gun began to replace the more cumbersome pole or rod. This precipitated another controversy, but the rods have been almost altogether replaced by the guns, in spite of the fact that slightly better results may often be obtained with the former. The guns are more easily handled, and allow greater pressures to be used, thus increasing the speed with which the trees may be covered.

In recent years, large portable outfits, capable of maintaining 400 pounds pressure or more and of holding 300 to 500 gallons of material, have been used for power spraying. These are gradually being replaced by stationary outfits, which, though somewhat more expensive to install, are more satisfactory and probably more economical in the long run.

---

*) 1908. Melander, A. L. — Filling the calyx cup; in Journ. Econ. Ent., vol. 1, pp. 217—220. — 1909. The calyx cup must be filled; ibid., vol. 2, pp. 67—78.

These installations usually consist of a thousand gallon tank of wood, steel, or concrete, a large pump operated by gasoline or electric power, and sufficient piping through the orchard to allow all the trees to be reached with lengths of hose not exceeding 100 feet, which may be attached to any of the numerous outlets provided.

Although Simpson*) in 1903 stated that commercially prepared lead arsenate was prohibitive in cost, it soon became the standard insecticide for controlling the codling moth. The number of spray applications in the Pacific Northwest has gradually increased from a calyx spray, or a calyx and one cover spray, to six or seven applications, or even more in badly infested sections. Recently there has been a tendency to use more than the standard quantity of 1 pound of dry lead arsenate to 50 gallons of water.

The increased number of applications, the practice of spraying late in the season, and the greater strength of material used, have precipitated the spray residue situation. Doubtless more than the recognized tolerance of arsenic has occurred on sprayed apples for many years, but the excessive quantity recently placed on the fruit and allowed to remain there has called the attention of health authorities to the danger from this source, and has made it imperative that something be done about it. The situation has been more acute in the Pacific Northwest because more spray is applied to the fruit there than elsewhere, and there is less rain to wash it off before harvest time.

In the emergency which has existed, methods for removing the residue have been developed rapidly. The need has become apparent, however, for a modification of the present spray practice. Two factors are involved. One is the demand for even more efficient control than that provided by a succession of lead arsenate applications. Even with the most efficient spraying, the lead arsenate becomes less effective as the season advances, as already pointed out in Dr. Porter's paper, and many worms survive. Many others succeed in producing blemishes on the fruit, known as "stings", before they are killed by the poison. Owing to the strict grading rules enforced in the West, these stings result in a considerable loss of salable fruit, and there is a demand for a control method that will result in few stings as well as few wormy apples.

The other factor is the need of evolving a spray treatment that will place on the fruit a minimum of material toxic to human beings. There is little or no hope of working out a method of control that will not put some poison on the fruit. But it is very probable that the present practice can be so modified that a subsequent washing or wiping of the fruit will make it absolutely safe for human consumption. At best, the cleaning of the fruit will not remove all of the spray residue, and this fact must be kept in mind. More than two applications of lead arsenate, in the arid regions of the West, will leave a residue on the fruit containing more arsenic than is permissible, and cleaning will be necessary. But, as already indicated, more applications must be made to effect control in most districts.

---

*) 1903. Simpson, C. B. The Codling Moth; in U. S. Dept. Agr., Div. Ent. Bul. 41. 105 pp., illus.

When the situation is analyzed it will be seen that the entomologist has a very difficult problem confronting him. In spite of its failings, the lead arsenate method of control is highly effective, extremely safe, and very economical. In attempting to modify this method a number of things must be considered.

First of all, any method must kill, or prevent from entering the fruit, more than 99% of all eggs or larvae, or it fails to meet the requirements of the western fruit grower. This is because commonly several worms are produced on a tree for each apple, and unless 99% or more of these worms are prevented from entering the fruit, several per cent of the fruit will be wormy. It must be admitted that many growers allow more than 5% of their fruit to become wormy, but the goal aimed at is 1% or less. With few other insects is it necessary to kill such a high percentage to effect satisfactory control.

Another requirement more or less peculiar to codling moth control is that any insecticide must remain effective for periods of from ten days to three or four weeks after being applied to the trees. With many insects control is effected by a single application, the insects being already present, but the habits of the codling moth make it imperative to place a coating of the insecticide on the tree and fruit before the destructive stage of the insect is present, and to renew this coating at not too frequent intervals.

In addition to these requirements, it goes without saying that the material be harmless to the tree or fruit, cheap, easily handled, and available in large quantities. Thus we must have an insecticide that is highly effective, that is stable and adhesive, non-toxic to the plant, and economical.

Entomologists have usually solved insect control problems alone. But as the difficulties increase, the entomologist must call to his aid the chemist and the plant physiologist. The solution of the problem must be the result of cooperative investigation, just as modern inventions are often the result of the efforts of a group of men rather than of one man. This has been recognized in the Pacific Northwest particularly, and we have there the Western Cooperative Oil Spray Project *). In this project the chemists, plant physiologists, horticulturists and entomologists of half a dozen government and state agencies are working on the common problem of determining whether or not mineral oil sprays may be used successfully for the control of the codling moth and other insects. Starting as an entomological problem, one of insect control, it went through a chemical phase, that of determining the most suitable types of oils and methods of emulsifying them, and it is now a problem chiefly within the province of the plant physiologist, one of determining whether any oils may be safely used on the plants. At the present time it may be said that oil, in conjunction with a certain quantity of lead arsenate, offers a very promising control measure for the codling moth, if the plant physiologist determines that there is an oil which will not materially injure the tree or fruit.

---

*) 1928. Report; in Science, vol. LXVII, No. 1744, pp. 560—561.

Among the organic insecticides being tried in the West, nicotine is giving some interesting results just now. Its chief drawback is its cost, but it must be remembered that lead arsenate was once considered too expensive for practical use. In the inorganic field, some of the fluosilicates offer possibilities.

Much attention has been paid in the Northwest, particularly by Newton*), Yetter**), Yothers***) and Spuler†). It has been shown that certain mixtures of fermenting apple juice or molasses, when placed in the tops of the trees, will capture thousands of codling moths even in moderately infested orchards. However, the baits alone will not give adequate control, neither has it been determined whether their use will take the place of part of the spraying schedule, nor what is the most attractive and economical bait.

Banding of the trees with burlap or other suitable material is a valuable mechanical means of control, though on the average probably not more than a third of the worms may be captured by this means. Ten years ago the banding of trees was little practiced in the West, but now it is a common means of supplementary control, especially among those fruit growers who, for one reason or another, are not particularly successful in obtaining control by spraying. The advent of the chemically treated band will no doubt make this method even more popular.

Summing up the prospects of improvement in our present methods of controlling the codling moth in the Pacific Northwest, it is the writer's opinion that changes will take place slowly and that the practice in the future will probably be about as follows:

(1) Lead arsenate will continue to be used in the calyx and early cover applications. Washing of the fruit apparently has come to stay, but excessive application of lead arsenate must be avoided.

(2) Later sprays will consist of oil, nicotine, or some other material, possibly one yet untried. This will reduce the residue hazard and will also reduce losses from worm "stings", as these materials kill the eggs or prevent most of the worms from "stinging" the fruit before they die.

(3) The spray program will be supplemented, even more than at present, by mechanical control measures, such as banding and baiting.

The problem for the entomologist in the immediate future is to determine the relative value of the various insecticides and other control measures and to work out the best practical combination of these measures for the fruit grower. A number of years will be required for the solution of this problem.

---

*) 1924. Newton, J. H. — Trapping Codling Moths; in 15th Annual Rep. State Ent. of Colorado (for 1923), pp. 29—31.

**) Yetter, W. P., J. — Codling Moth Traps; ibid., pp. 32—38, illus.

***) 1927. Yothers, M. A. — Summary of Three Years' Tests of Tap Batts for Capturing the Codling Moth; in Journ. Ec. Ent., vol. 20, pp. 567—575.

†) 1927. Spuler, A. — Codling Moth Traps; in Wash. Expt. Sta. Bul. 214, 12 p., illus.

The Control of some imported Tree Defoliating Insects.

A. F. Burgess, Melrose Highlands, Boston, Mass.

(With 6 text-figures.)

It is a well established fact that noxious insects introduced into a new environment, if they survive at all, usually become more destructive than they are in their native homes. There are many reasons why this is so which are unnecessary to stress before a meeting of this kind. The United States has suffered severely in this respect, but other countries have had, or are likely to have similar experiences in the future as rapid communication and exchange of products yearly becomes more universal. Every kind of plant and animal life is exposed to these hazards and their constant shipment increases the opportunity for the establishment of new pests. Serious efforts have been made in the United States to meet this situation by the enforcement of quarantine and regulatory measures for the purpose of minimizing the dangers and by endeavoring to introduce natural enemies that give promise of being helpful in reducing the damage.

The protection of shade, ornamental, fruit trees and forests forms an important part of the activities that are designed to bring under control the destructive insect enemies which threaten the welfare of mankind. While it is doubtless true that many countries, due to their location, more restricted area and less diversified agriculture, have not encountered as great financial losses as the United States, it would seem wise to accumulate a store of knowledge relative to their problems in order to meet any emergency that may arise in the future.

I assume that it is the mission of the Entomologist so to conduct his activities that the results of his work may be applied for the benefit of his countrymen and thereby contribute to the protection and welfare of the country to whom he owes his livelihood and allegiance and to the world at large.

Without making any attempt to enumerate the number of species of tree defoliating insects, either imported to the United States or native, that are a source of constant drain on development of forest and shade trees, it is well known that the annual financial losses caused are enormous. Dead and dying trees give visible evidence of the damage caused by insect defoliators, but uncomputed and frequently unobserved losses constantly result from these causes which are recognized only by the expert, and result in retarded growth or render the trees more susceptible to borers or pathologic diseases. This being the case, any country is warranted in making relatively large expenditures to prevent the establish-

ment and curtail the spread of new pests that may become established in a limited area.

The northeastern Atlantic States have been most unfortunate in receiving during the past fifty years several foreign insect pests which have caused vast losses in that section and are a menace to the country at large if their spread cannot be restricted. One of the notable species concerned, and the one that arrived earliest, was the gipsy moth *(Porthetria dispar* L.), which became established at Medford, Massachusetts, near Boston in 1868, and is the species around which the subject matter of this paper centers. This insect was followed in 1897 by the brown-tail moth *(Nygmia phaeorrhoea* Don.), another European pest which has caused serious damage in this country to deciduous trees for more than 20 years and is still an important pest in rather restricted areas in New England, particularly near the Atlantic seaboard. The Oriental hag moth *(Cnidocampa flavescens* Walk.), from Japan, became established in Boston in 1906. It has spread very slowly, but is frequently abundant and destructive to shade trees in Boston and vicinity.

In 1920 the satin moth *(Stilpnotia salicis* L.), an insect indigenous to Europe and Asia, was found in Medford, Massachusetts. It defoliates all varieties of poplar and willow trees, has spread westward beyond the Connecticut River, more than 100 miles from Medford, and to a far greater distance north and northeast, it having reached Bangor, Maine. This insect also occurs in Vancouver, British Columbia, and in the western counties of the State of Washington on the Pacific coast.

In addition to these species, the Japanese beetle *(Popillia japonica* Newm.), which is of Japanese origin and causes midsummer defoliation of fruit and shade trees, was first found in New Jersey, not far from Philadelphia, in 1916, and the European corn borer *(Pyrausta nubilalis* Hübn.), which is a pest of cereal and forage plants, was found near Boston in 1917.

From 1890 to 1900, when the gipsy moth was a severe pest in a region embracing about 350 square miles around Boston, a strenuous effort was made by the State of Massachusetts to bring about its extermination. During the last part of this period the State conducted field operations to control the brown-tail moth. Both of these insects were so reduced that there was no noticeable injury to trees at the time the work was abandoned in 1900. Five years later thousands of acres were being defoliated annually and the crawling larvae became so abundant in residential sections that popular protest at the intolerable conditions forced the resumption of control work. By this time sections of Maine, New Hampshire and Rhode Island had become infested and the Federal Government was induced to carry on work to relieve the situation.

The importation of parasites and natural enemies of these insects was begun under the direction of Dr. L. O. Howard and a determined effort made to prevent the spread of the pests in New England and their transmission on long distance shipments to other parts of the United States. The area infested by the gipsy moth was so densely infested that it was impossible to prevent local spread for many years. The brown-tail moth, on account of the ease with which the moths fly, spread more rapidly and soon increased its range throughout the territory extending

west of the Connecticut River and including the southern half of Maine, and to New Brunswick and Nova Scotia in Canada.

During the last few years the increase of the brown-tail moth has been curtailed largely as a result of the increase of introduced parasites, extreme low temperatures during the winter in certain sections, and scarcity of favored food plants in some parts of the area. A fungus disease *(Entomophthora aulicae* Reich.) has also been a factor in reducing the insect where climatic conditions were favorable to the development of the disease. In the cities and towns where food plants were favorable to the species it has been reduced in numbers by cutting and burning the winter webs and spraying with arsenate of lead in the early spring.

No such combination of natural enemies and local conditions has been as effective in restricting the spread of the gipsy moth. Isolated areas have been discovered outside the main infested area in Connecticut, New York, Pennsylvania and Ohio, but the insect has been exterminated in these situations by the effective use of field control measures. Parasites, extreme low temperatures in the winter which kills the eggs in the clusters that are deposited in unprotected situations, a dearth of favored food plants in certain areas, overpopulation producing wholesale starvation in some localities, and the presence of the wilt disease which appears to flourish when the larvae are weakened by insufficient or improper food, have reduced infestations during some seasons, but for nearly 15 years after the problem was vigorously attacked by the Federal, State and local authorities, gradual spread of the insect continued.

In July 1920, a vigorous colony of the gipsy moth was found by State inspectors near Somerville, New Jersey. It originated from several large consignments of trees secured in Europe and assembled and shipped from Holland about 1912. Control operations were immediately organized by the United States Bureau of Entomology, in cooperation with the New Jersey Department of Agriculture, and it was found that the area infested embraced more than 400 square miles. Over 3,000,000 egg clusters of the insect were destroyed during the first year of operations. Many trees were dead and dying and a considerable acreage was completely defoliated at the time the colony was discovered, but no noticeable foliage injury has been found after active clean up work was well under way. Eight years of intensive work under the same management has resulted in a constant reduction of the infested territory, so that less than one-half of the original area now requires attention and the elimination of the insect from New Jersey will be accomplished in a very few years (text-figs. 1, 2).

Such work must be organized efficiently and the men trained in the methods employed. They must be instructed and secure experience in locating the egg clusters of the insect, the best way to treat them with creosote, the use of bands on the trees and the methods of application that will be most effective, the methods of spraying efficiently under all kinds of conditions and many other important details. Reliability of personnel is the keynote to success in an operation of this kind.

The urgent problem in New England was to prevent the spread of the insect to the west. From 1906, when Federal work began, until 1921, some westward spread was found nearly every year. This was coincident

with enormous defoliated areas, particularly in southern New Hampshire, eastern Massachusetts and northern Rhode Island. In spite of the utmost efforts that were made to restrict the spread of the insect, supplemented by intensive work by the State authorities in the territory east of the outside rim of infestation, these conditions continued. During this period parasites and natural enemies were imported from Europe and Japan. 47 species have been received and liberated in New England; of this number fifteen species have become established, but only ten have increased so as to be recovered in numbers in field collections. These species include the two egg parasites, *Schedius kuvanae* How., and *Anastatus disparis* Ruschka, the Tachinids *Compsilura concinnata* Meig., *Sturmia scutellata* Rob.-Desv., the Hymenopterons *Apanteles melanocephalus* Ratz. and *Hyposota disparis* Vier., and the predaceous beetle *Calosoma sycophanta*. The other three species that survived in numbers, *Apanteles lacteicolor* Vier., *Meteorus versicolor* Wesm., and *Sturmia nidicola* Towns., are parasites of the Brown-tail moth only.

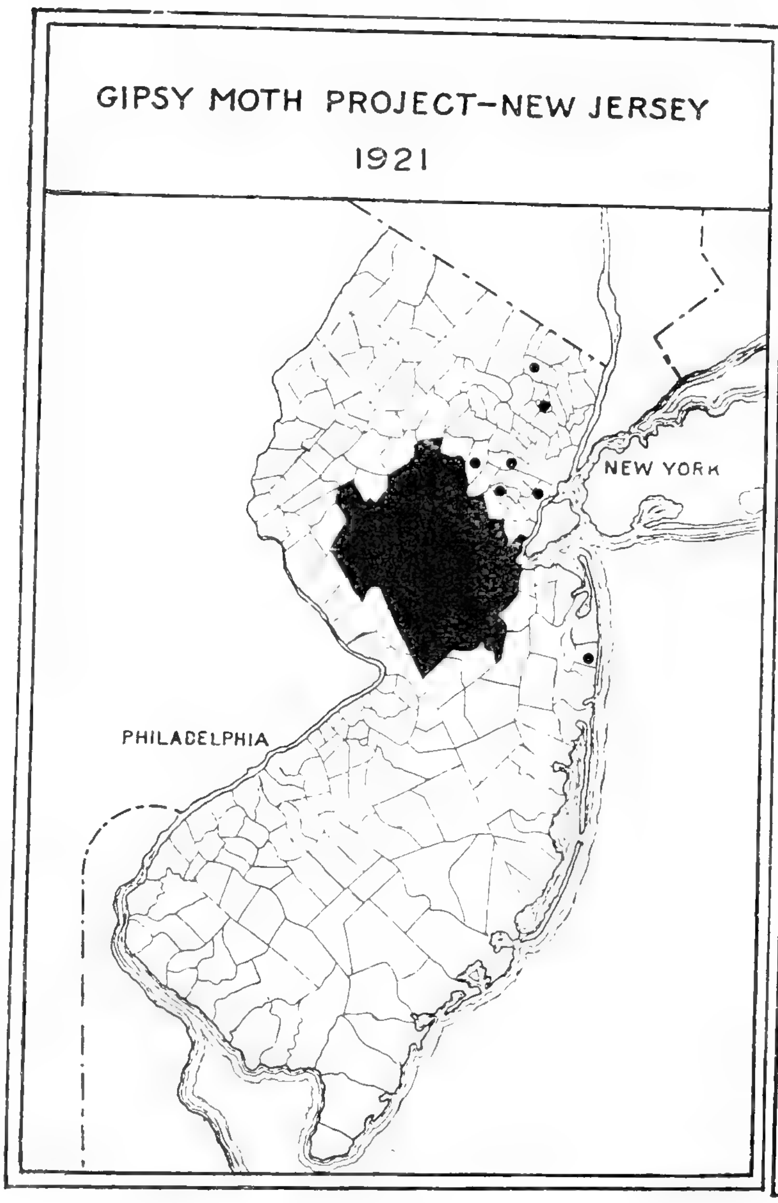


Figure 1.
Infested area indicated in black.

Figure 2. Infested area indicated in black. Black lines enclose areas where scouting and clean up work has exterminated the insect.

The increase of these species in the field was remarkably slow and years of careful study have been required to secure the results already accomplished. During the progress of this work which was the first attempt made in the United States to introduce parasites of an insect on so large a scale, an enormous fund of scientific data have been secured

at the Gipsy Moth Laboratory at Melrose Highlands, Massachusetts, which have been most helpful to other investigators working on similar problems.

In the fall of 1922 several gipsy moth colonies were found in New York State in towns adjoining the Massachusetts line.

In the summer of 1923 the acreage of defoliation in the older infested areas was the lowest of any time for twenty years and the percentage of parasitism was the highest. The following year the abundance of parasites dropped sharply and since then the acreage of defoliation has increased each year with only a moderate increase in parasitism.

Vigorous enforcement of a Federal quarantine providing that products likely to carry infestation could not be moved without inspection has been in effect since 1913 and has prevented the spread of the insects on products that were shipped to every State in the Union.

In 1923 a barrier zone was established extending from the Canadian border to Long Island Sound east of the Hudson River in New York, including territory in western Vermont, Massachusetts and Connecticut, averaging about 30 miles in width and over 250 miles long. The purpose was to examine the area and exterminate the colonies found in order to make it impossible for large colonies to become established, so that further spread of the insect to the west could be prevented. The portion of the zone in New York State was worked jointly with the Department of Conservation of that State, while the balance of the zone was managed by the Bureau of Entomology, the States concerned carrying on as much work as possible in the area east of the zone.

Numerous colonies were found as a result of the initial inspection of the area, all of which were thoroughly treated. In so large an area it was impossible thoroughly to scout all the woodland and this of necessity has to be given attention over a period of years. In 1924 a bad infestation was found in Canada near the International Line by the assistants of the Dominion Entomologist. It has been exterminated by the Canadian authorities.

As the acreage of defoliation was very low in the eastern part of the infested area in 1923, conditions were very favorable for the prosecution of effective work in the barrier zone, as the opportunities for the spread of the insect were greatly curtailed. Better results have been accomplished in the zone than was at first anticipated, for in addition to cleaning up most of the colonies, fewer new ones have been found nearly every year and the spread of the insect has been checked (text-figs. 3, 4).

Unfortunately, defoliation began to increase in 1924 in the oldest infested area, the acreage rising sharply near the seacoast, intreasing in amount and becoming more intense to the westward each year. The rate of parasitism has not kept pace with the increase of the insect and it is impossible to tell how many years may elapse before low defoliation will result. The area directly east of the zone is becoming more heavily infested each year and is a grave menace to the success of the project unless work can be undertaken to protect it without delay. The situation in this respect is critical at the present time.

For over twenty years the Federal Government in cooperation with the States concerned have waged a relentless war against this insect, the

average expenditures totalling over $1,250,000 annually. The area in New Jersey is being rapidly cleared of the pest and the maintenance of the barrier zone in New England and eastern New York, together with the quarantine measures in force, have thus far afforded protection to the States to the west and relieved them from large annual losses and the expenditure of large sums for control work.

Research work has aided materially in improving the methods of operation and making possible more effective means of carrying on this extensive project. The importation of parasites and their successful colonization has helped materially in reducing the pest locally and over large

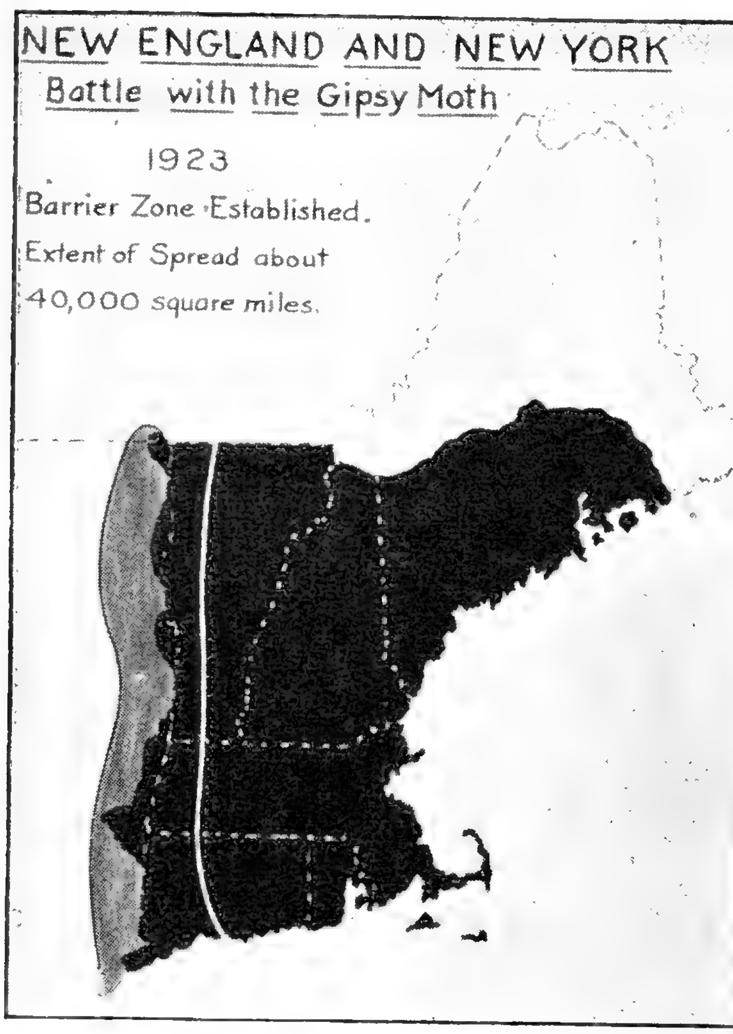


Figure 3. Infested area indicated in black. Barrier Zone indicated between black and white line.

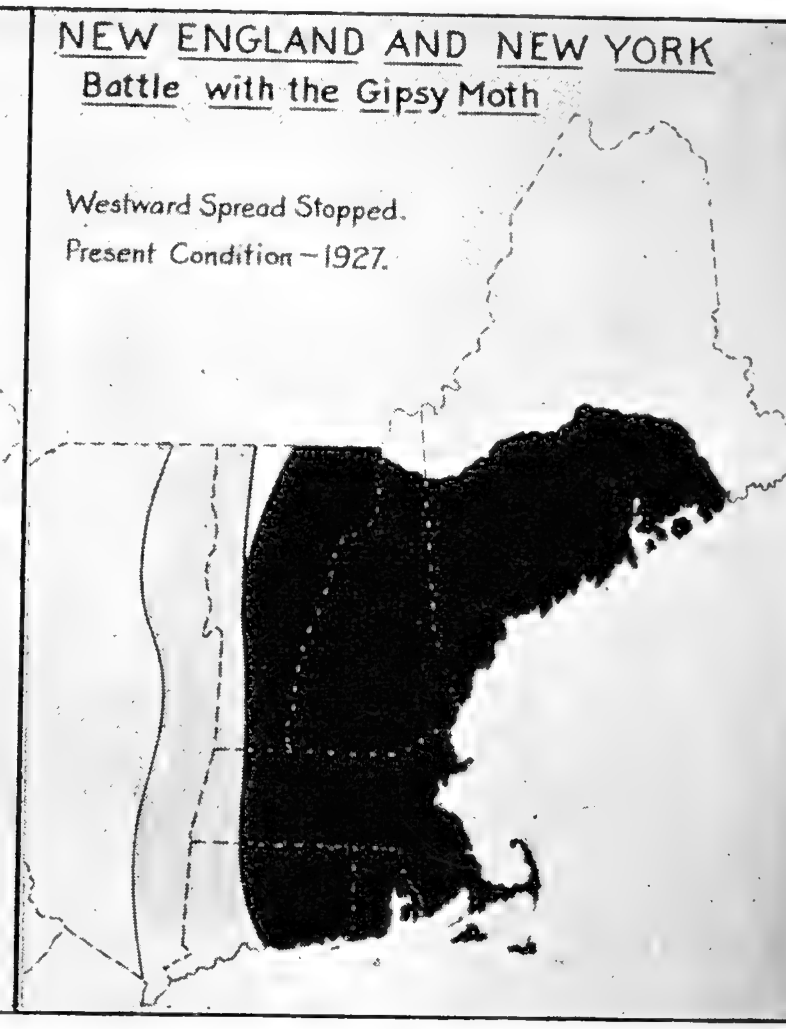


Figure 4.
Infested area indicated in black. Barrier Zone infestation reduced.

areas during certain years, but at present gives no assurance of effecting constant control, but this work is being continued. Improvements in insecticides and the machinery for their application have been constantly made so that it is now possible to spray more effectively and economically than ever before. The heavy duty auto truck sprayer has replaced the hand pump mounted on a small barrel (text-fig. 5, 6). Climbing of trees is no longer necessary in order to spray them effectively. Paris Green and London Purple, which were the standard insecticides when the gipsy moth work was begun by the State of Massachusetts in 1890, have been replaced by arsenate of lead, a far more efficient insecticide and one which was first made and applied by that State on the gipsy moth work and has since been adopted for world wide use. The use of fish oil as a sticker has in the last few years made spraying of shade and forest

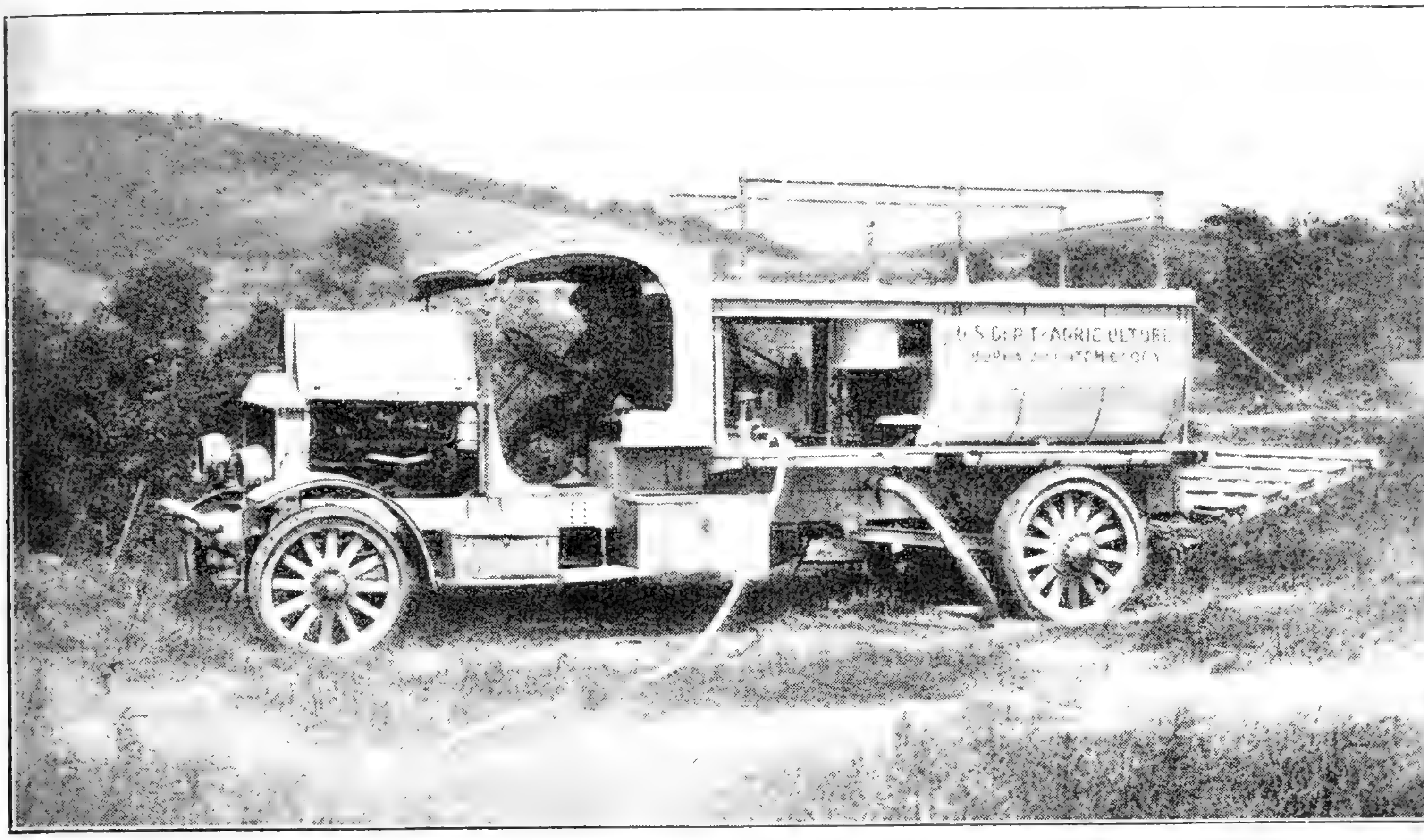


Figure 5. High power auto truck sprayer.

Figure 6. Solid stream spraying. Power furnished by sprayer illustrated in Figure 5.

trees more effective with a decreased dosage of poison. These and innumerable other improvements have served to render the work on this project more efficient and have encouraged more effective and better control of shade tree insects in general.

All this has been accomplished by the efforts of many men, trained scientists numbering several hundred since the beginning of the work by the State of Massachusetts, and including such eminent names as the late Dr. C. H. Fernald and his son, Dr. Henry T. Fernald, Lounsbury, of South Africa, Cooley, of Montana, Felt, of New York, Townsend, now in Brazil, Thompson, now with the Imperial Bureau of Entomology in England, Tothill, formerly with the Dominion Entomologist Office of Canada, now in Fiji, McLaine, of Canada, Harry Smith and Timberlake, of California, together with the present staff now on the project and a host of others now employed by the Bureau or by the States, who, under the direction of Dr. Howard, have contributed materially to the progress of the work. More than a score of State officials together with their assistants have had an active part in this project and by their earnest cooperation have made possible many of the results secured. There is another group, many of whom are now leaders in the great quarantine and control projects in this country both State and Federal, who have had a share in bringing the gipsy moth work to the state of development which it enjoys today. These, including the present organization now operating under the Plant Quarantine and Control Administration of the United States Department of Agriculture, together with thousands of men who have served in less prominent capacities, have worked unselfishly in sunshine and in shadow to bring success to this project.

The gipsy moth work has demonstrated that it is possible and entirely practical to restrict the spread and reduce the area infested with an insect of this type. Although the female moths do not fly, the egg clusters may be carried long distances on material that is shipped and the newly hatched larvae are spread rapidly by the wind, particularly from areas that are heavily infested. The results secured with the gipsy moth indicate that research and experience will develop more perfect methods to curtail and control other pests that spread more rapidly and menace the crops of this country.

Morphological and Oecological Studies on Chrysopa chrysops L.

Dr. M i l a d a C e b e o v a , Charles IV. University, Prague, Czechoslovakia.

(With 4 text-figures.)

Devoting my small work to the study of the morphology and biology of *Chrysopa* I have found a very good monograph of K ä t e P a r i s e r: „Beiträge zur Biologie und Morphologie der einheimischen Chrysopiden", published in the A r c h i v f ü r N a t u r g e s c h i c h t e , A., Heft 10, Berlin, 1917. I was interested in some questions referring to these insects, and I have come to some conclusions, based upon my observations, which supplement the work mentioned above.

My observations have been carried out on *Chrysopa chrysops* L., because I found this species very often in various localities, and I was especially interested in some cardinal points: observations concerning the laying of its eggs; the morphology of the egg (chorion, micropyle); description of the egg-breaker (ruptor ovi) of the embryo, study of the hatching of the larvae and their development; description of the various stages of the larva; study of the morphology of the last abdominal segments of the larva; description of the changing to the pupa; and observations on the oecology of *Chrysopa.*

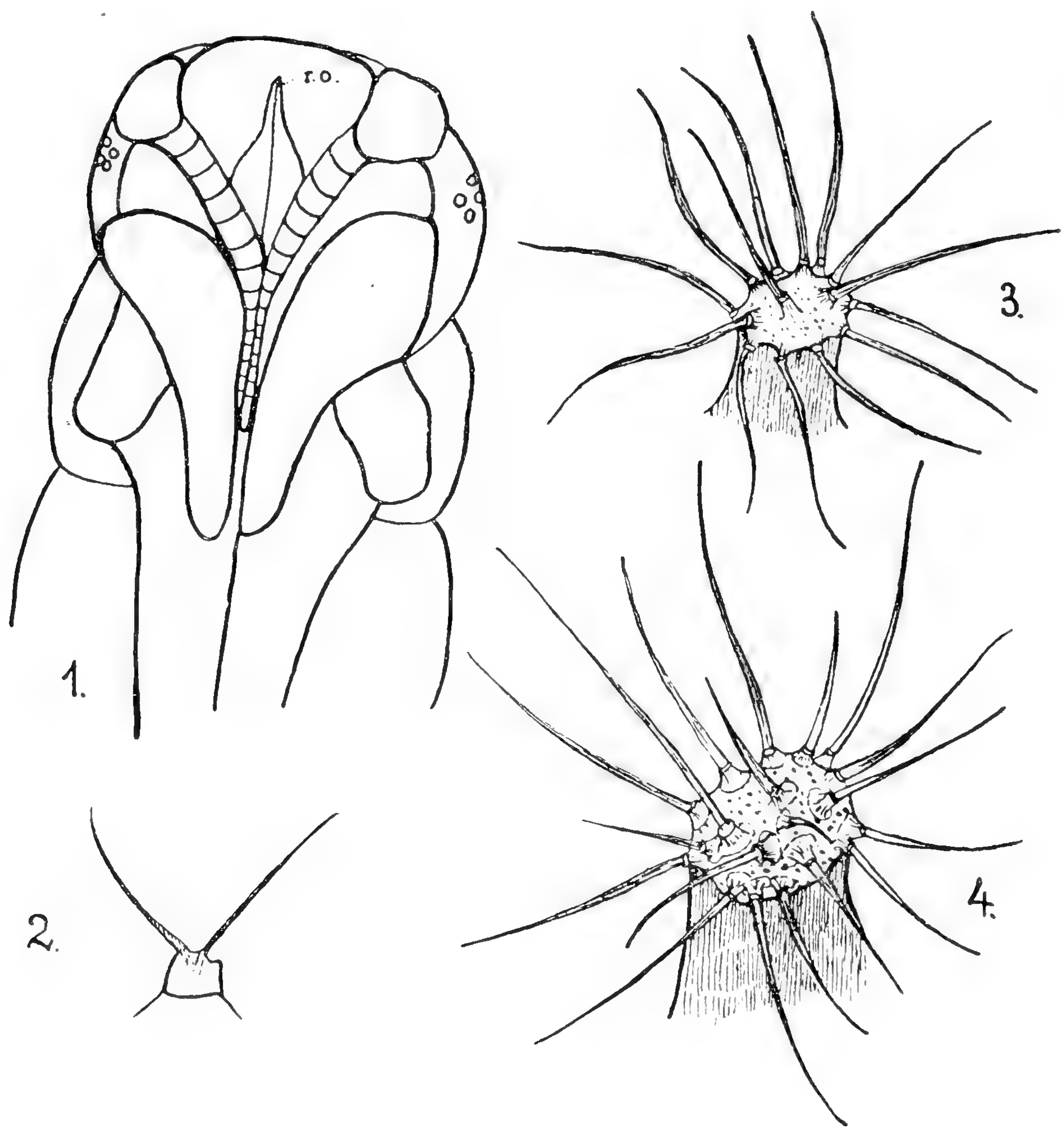
When the female of *Chrysopa* desires to lay eggs, she finds out a convenient place on the leaves or on the twigs, stops, and her abdomen performs then several times a movement, by turns touching the leaf and rising up again. The last movement upwards is then effected slowly, and we can see already a very thin thread, which is fixed with one end to the leaf and is carrying at the other end, where the abdomen has finished its movements, a little clear greenish egg. The female waits with the raised abdomen till the thread grows hard, and then, with a slight movement, she gets completely rid of the egg. In this way, at varying intervals, the female lays about 12 to 25 eggs during a day.

Chorion of egg: apparently wholly smooth, appearing under the immersion as a skinny, milk-like membrane, composed of small cells with 4 to 7 angles, the corners of which are mostly indistinct.

The micropyle has the form of a disc and appears under great enlargement as a flat funnel, with a dark spot, containing several projections, at the bottom the aperture of the micropyle. The walls of the funnel have regular ridges converging towards the middle. The total detailed structure is conforming with the structure of the chorion, but is finer.

The development in the egg was never longer than 5 to 6 days. At this time the embryo is very well visible through the transparent membrane of the egg, first as a clear yellow streak, then as a red streak, when the segments of the body appeared, and was always growing dark. During the last two days, the extremities and the ocelli of the embryo become also already visible.

On the head of the embryo (text-fig. 1), shortly before the hatching of the larva, we can see a dark, small streak, extended from the vertex to between the mouth parts, which are appressed to the body. This is the egg-breaker or "ruptor ovi" (r. o.), which, after the preparation of the embryo out of the egg, shows the form of a strongly chitinized little helmet, with a sharp long tip. It serves the embryo for the opening of the egg. The "ruptor" falls off immediately the larva appears free, together with the embryonic cuticle. As the organ is situated on the frons of the insect, it may be called frontal.



The body of different stages of the larva does not show many differences in shape. It is straight, elongate, resembling in form a spindle which is flattened above. The ground colour is a clear grayish yellow, with dark brown spots on various segments and with a black marking on the head.

The mouth parts consist of a small labrum, and a labium with labial palpi, entirely closing the opening of the mouth. The function of a mouth is undertaken by the little sucking tube formed by the grooves in the mandibles and maxillae, which lie tightly together. Their sharp ends spear the prey, which is then sucked out with the help of the tubes. The tips of the mandibles carry very fine indented teeth, turned backwards, which render the tube difficult to be pulled out of the wound. Antennae long, filiform; six ocelli placed close together in a spiral.

On the sides of each segment of the body (excepting the 1., 9., 10., 11.

abdominal) are particular knobs carrying tubercles with long hairs. Similar structures are found on all segments (except the prothorax, 9., 10., 11. abdominal), always arranged in one or two belts, each containing 2 to 6, and placed in the middle of the segment. Prothorax and the 1. to 8. abdominal segments each with a pair of stigmata.

The last two segments of the abdomen have a completely different form from the others. The tenth segment is reduced to two triangular side-valves. The eleventh segment lies between these valves, overlapping them a very little.

Fig. 2 represents a prothoracic tubercle of the first instar, fig. 3 the same of the second instar, and fig. 4 the same of the third instar.

The feet of the larva, covered with few little hairs, carry at the tip of the uni-articulated tarsus two sharp claws, and between them we find the "pulvilli" on a thin scape.

The first stage of the larva is remarkable, especially by the great dimensions of the head and of the prothorax, by the length of the mouth parts, by the feet and the little hairs on the tubercles. But these peculiarities disappear wholly during the development, and the larva approaches in its form the general type. The first moulting takes place in about 3 to 6 days. The second stage, and also the third, which follows in 3 to 6 days after the second stage, do not show many distinctions, excepting larger size. The real distinctions between all stages consist only in the articulation of the tubercles and in the differences of the marking on the head.

The following table may be useful for distinguishing the larval instars:

1. first stage: either
   a) clear, transparent, about 1.8 mm long, 0.5 mm large,
   or b) about 3.8 mm long, 0.8 mm large, wholly coloured; the knobs on the pronotum divided in 2, mostly 3 tubercles, with the same number of long hairs.
2. second stage: about 6 mm long, 1.5 mm broad; the marking on the head dark with a small clear point on the back side; the knobs on the pronotum with about 12 to 17 tubercles and hairs.
3. third stage: 9 to 10 mm long, 2 mm broad, a complicated mark on the head; the knobs on the pronotum with about 20 tubercles and little hairs.

The larva of the third stage lives 8 to 10 days, and spins then a cocoon in a protected place and changes into the pupa.

In the cocoon it moults once more, changes into a chrysalis, passes the winter and creeps out in the spring ready for the emergence of the imago in the neighborhood of the cocoon.

The adult of *Chrysopa chrysops* lives from the end of May or beginning of June till the end of July or the first days of August. The length of the adult's life is about one month. The development from the laying of eggs till the changing of the pupa takes from 23 to 30 days, so that the entire development of *Chrysopa chrysops* inclusive of the winter takes 9 or 10 months.

The most favourite food of *Chrysopa* are Aphids and Coccids of all sorts. During its life (larva and imago) *Chrysopa* destroys about 500 to 800 Aphids. The species, therefore, must be considered as useful.

Adaptations which hinder or prevent Inbreeding in Insects.

Professor E. B. Poulton, F. R. S., Oxford, England.

My attention was first directed to the importance of this subject by a series of breeding experiments, carried on since 1917, upon the abundant British Geometrid moth *Abraxas grossulariata* L. The injurious effect of inbreeding became obvious in the third generation and in only a single family was it possible to obtain a few moths of the fifth [1]). The fatal effect manifested itself in all stages. The larvae often died when fully formed in the egg, and those which hatched died at various periods. The pupae, too, often failed to produce living moths. One of the most marked effects of inbreeding is a slower rate of growth and development, often leading to surprising results. Thus a larva of the second inbred generation, which hatched in July 1921, was only about half-grown when it was exhibited to the Entomological Society of London on 18th October 1922! It had been observed feeding on that day and was still alive on 28th November, but died a week later [2]). Another interesting effect commonly seen in the pupae of inbred *A. grossulariata* is the substitution of a probably ancestral reddish brown tint for the characteristic intense black which, with the bright yellow bands, gives the well-known wasp-like appearance.

Many years before these experiments were undertaken, the remarkable all-female families of *Acraea encedon* L., bred by W. A. Lamborn in the Lagos district, together with other families in which males predominated, led to the hypothesis of an adaptation for the promotion of crossbreeding [3]). But it was the suddenly realised interpretation of the puzzling behaviour of a Saturniid moth, observed forty years earlier, which led me to think that adaptations to prevent inbreeding are probably widespread among insects.

In 1887 I was anxious to observe the larval stages of the European Emperor Moth, *Aglia tau* L., and had obtained a number of pupae, fully expecting that the moths, of which the males are well known to "assemble", would pair freely and that plenty of fertile eggs would be laid. To my astonishment only a single pairing was obtained, while many males and females, emerging in the same cage at nearly the same time, died without taking any notice of one another. The solution is, I believe, that active

[1]) The late Arthur Bacot, who had great experience in breeding Lepidoptera, once told me that he had never succeeded in rearing a fifth generation of inbred moths.

[2]) *Proc. Ent. Soc. Lond.*, 1922, pp. lxxvi, xcv.

[3]) *Ibid.*, 1911, pp. liv, lv; *Linn. Soc. Lond., Journ. Zool.*, Vol. XXXII, Sept. 1914, p. 391.

flight is necessary for the males before they become susceptible to the scent of the virgin females, but active flight under normal conditions would carry them far away from the females of their own family. Were it otherwise, their remarkable powers would lead directly to inbreeding; for the females of "assembling" males are heavy, sluggish insects and lay their eggs in a limited space [1]).

During the past months many examples of this and other adaptations for the same end have occurred to me or have been suggested by the kindness of friends. A brief account of these will, it is hoped, induce others to look for further evidence which I am convinced exists on a very large scale. The adaptations may be classified under the following barriers against inbreeding: — Time, Space, and Physiological.

A. Time Barriers.

Emergence of sexes in the same family at different times: — The commonly observed emergence of males before any of the other sex have appeared has been regarded as an adaptation to ensure full and free competition for the females, but it also tends to encourage cross-breeding in the same manner as the delayed male susceptibility of other species. The early emergence of the males results in their dispersal, taking them away from the females of their own families [2]). In some insects the barrier of time appears to be complete, and inbreeding entirely prevented. Thus E. Lindner [3]), when rearing *Cnethocampa pityocampa* Schiff., in captivity, has found that the females emerge in July of one year and the males in July of the following year; also that in captivity the females of *Saturnia pavonia* L. and *spini* Schiff. stay over an extra winter far more rarely than the males. Dr. V. G. L. van Someren [4]) has shewn that there is great inequality in the sexes of the families reared from the eggs laid by females of *Acraea esebria* Hew., sometimes males, sometimes females preponderating. There was, however, practical equality (46 ♂♂ to 45 ♀♀) in the largest family, with a great excess of males among the earlier emergences and of females among the later, and indications of the same kind of sequence in some of the smaller families. Such an alternation of sex predominance in successive waves of emergence would, of course, tend to hinder inbreeding. In examples such as these, however, the difference of time, combined with the power of flight, would lead directly to the barrier of space.

Dr. J. W. Munro [5]) has brought forward evidence which suggests that the males of the Sawfly, *Lophyrus pini* L., may emerge some considerable time before the females of the same brood.

[1]) *Proc. Ent. Soc. Lond.*, Vol. II, 1927, pp. 75—82.

[2]) The emergence of male insects before their females have appeared is utilised by certain Orchids for securing cross-pollination. The flowers attract the males by a rough resemblance to the females, and probably, even more effectually, by a scent like that of the female. An abstract of the work of Pouyanne and Godfery on this subject is given in *Proc. Ent. Soc. Lond.*, 1927, Vol. II, pp. 31—33. Mrs. Coleman has recently shewn that the male of an Ichneumonid, *Lissopimpla semipunctata* Kirby, is thus utilised by an Australian Orchid: *The Victorian Naturalist*, xliv, p. 20, May 1927.

[3]) *Zeitschr. f. wiss. Insektenbiol.*, 9, 1913, pp. 379, 380.

[4]) *Proc. Ent. Soc. Lond.*, Vol. II, 1927, pp. 5—10.

[5]) *Ibid.*, *vol. III*, 1928, p. 34.

Mr. J. V. Pearman, who has had much experience with the British *Psocidae,* kindly informs me that "in several species there is a marked difference in the rate of embryonic development within eggs of the same batch laid by a single female, some of the eggs hatching within a month and the others not until nearly six months later." He has, however, as yet no evidence bearing on the proportion of the sexes in the earlier and later hatchings.

B. Space Barriers.

(1) The winged sexual forms of social and some gregarious insects: — The flight of the sexual forms from the nest or community not only leads to the founding of new societies, but also tends to prevent their development from an inbred stock. In many species the worker ants of the nests over a wide area, by driving off their winged males and females in separate waves, and in response to some climatic stimulus, on the same days, create a mixed swarm in which the chances against inbreeding are very high. The care in keeping the sexes separate in the nest was forcibly brought to my notice when observing a small nest of *Iridomyrmex emeryi* Crawley, in the Blue Mountains, N. S. W. All the winged females crowded the floor of a low chamber, while all the winged males were hanging as densely packed from the ceiling [1]). Although the Social Hymenoptera supply the most obvious instances of cross-breeding promoted by dispersal, similar facts are conspicuous in the Aphides and other communal Homoptera. In the *Psocidae,* too, Mr. Pearman tells me that "migration and dispersal of the colony may take place before any oviposition (and possibly pairing), although sometimes there is oviposition (and possibly pairing) before the colony scatters."

The creation, by dispersal, of a space barrier against inbreeding naturally suggests concentration for the promotion of cross-breeding, a good example being the adaptive instinct which leads sexually mature insects to seek high points in the landscape, where the scattered males and females from many parts of a wide area can meet [2]). Or again, there is the gregarious instinct in migration which leads "to the streaming of large populations, and not of small batches of individuals, from an area of high pressure" [3]), thus ensuring that a new colony if established will not be inbred.

(2) Families of one sex or with the sexes numerically unequal: — Families of these kinds are probably common in Lepidoptera, especially in the species with gregarious larvae where inbreeding would be especially likely to occur. The first example known to me was observed by the late Dr. W. Hatchett Jackson in the companies of *Vanessa io* L., which were found to be "principally, but not entirely, of one or of the other sex" [4]). Lamborn's families of *Acraea encedon* have been already quoted, but it is necessary to draw attention to his important evidence that there are in this species two strains of females, both requiring fertilization, but one producing all-female offspring, the other mixed sexes

---

[1]) *Entom. Monthly Mag.,* 3rd Ser. Vol. VIII, May 1922, p. 124.

[2]) *Proc. Ent. Soc. Lond.,* 1904, pp. xxiii—xxvi.

[3]) *Trans. Ent. Soc. Lond.,* 1902, p. 464. See also Prof. Vernon L. Kellogg in *Proc. Ent. Soc. Lond.,* 1904, p. xxii.

[4]) *Trans. Linn. Soc. Lond.,* 2nd Ser., Zool., Vol. V. Mem. 4, 1890, p. 156.

often with a preponderance of males. Similar evidence for the existence of all-female-producing and mixed-sex-producing strains of *Hypolimnas bolina* has been recently obtained by H. W. Simmonds in Fiji[1]). Dr. V. G. L. van Someren has bred a great preponderance of females (66 ♀♀ to 22 ♂♂) from the ova of *Acraea rangatana* Eltr., collected from the food-plant[2]). In the *Pierinae*, Miss M. E. Fountaine bred 32 females of *Mylothris spica* Möschl., from a batch of ova found on a leaf[3]), and Lamborn has recorded evidence which suggests that a preponderance of males may be produced by *Mylothris rubricosta* Mab[4]). Among the moths, Prof. J. W. Heslop Harrison, F. R. S., has observed families with preponderant females among the *Geometridae*[5]).

Dr. J. W. Munro, D. Sc.[6]), has observed that batches of cocoons of an undetermined *Bracon*, from individual larvae of the weevil *Hylobius abietis* L., "yielded only one sex, now male, now female." The females of this *Bracon* observed in his laboratory always paired, and he has no reason to suppose that the parents of the unisexual families were parthenogenetic. He has also observed that only females of the weevil *Strophosomus coryli* F. were to be taken in spring, the males appearing in June. He suggests that there is a preponderance of female broods in the late summer and that these over-winter and account for the predominance of this sex in spring.

Dr. J. G. Myers[7]) has brought forward many additional records. Omitting on the present occasion consideration of all-male and all-female parasitic Hymenoptera, the following two examples are quoted from the Diptera: — (1) An Indian *Chrysomyia (Calliphoridae)* in which Prof. T. Bainbrigge Fletcher[8]) found that "under the same climatic conditions in captivity one female will produce only males, whilst another will produce females"; (2) the great predominance of females found by R. R. Parker[9]) among the various species of flies which emerged from one privy-vault in Montana. Dr. Myers thinks it likely that the great disproportion may indicate broods of one sex, and he points out that in carrion-feeding species "such tremendous numbers sometimes emerge from one small carcase which has been 'blown' by comparatively few female flies, that were the offspring in the usual nearly equal proportions of the sexes, the closest in-breeding would tend to result".

The interesting results obtained by Dr. E. Hindle[10]) in families of Lice *(Pediculus humanus)*, which were all-male, all-female, predominant male, or predominant female, are probably adaptations to prevent inbreed-

---

1) *Proc. Ent. Soc. Lond.*, Vol. III, 1928, p. 43, Mr. Simmonds's final conclusion, after a prolonged series of experiments, was announced at the meeting of June 6, 1928.
2) *Ibid.*, Vol. II, 1927, p. 9.
3) *Ibid.*, Vol. II, 1927, p. 75; III, 1928, p. 18.
4) *Ibid.*, 1923, pp. xcii—xciv.
5) *Ibid.*, Vol. III, 1928, p. 18.
6) *Ibid.*, Vol. III, 1928, p. 33.
7) *Proc. Ent. Soc. Lond.*, Vol. III, 1928, p. 41.
8) *Scientific Repts. Agric. Res. Inst. Pusa* (1916—1917), Calcutta, p. 91—102.
9) *Ent. News*, Philadelphia, xxix, pp. 145—146.
10) *Parasitology*, Vol. 9, 1916—17, p. 259.

ing; for the late A. Bacot[1]) hat shewn that the habits of these insects are such as to expose the species to this danger.

(3) Flight necessary for the male before developing susceptibility to the scent of the virgin female. — Many examples of delayed susceptibility in the males of "Assembling" moths are quoted in the Proc. Ent. Soc. London for October 1927[2]), where numerous observations, kindly placed at my disposal by experienced naturalists, are brought forward, together with a discussion of Fabre's charming writings on the subject. The experience of others, referred to in this little paper, was confirmed by Mr. J. A. Simes[3]), who in 1926 observed that males and females of *Saturnia pavonia* L. (= *carpini* Schiff.), emerging in the same cage, refused to pair. He had been led by this to conclude "that a period of flight on the part of the male was essential to pairing". Dr. G. V. Bull[4]) has supported this opinion by his observation that a bred male *S. pavonia* paired after dashing himself about in the cage; and Dr. Eltringham[5]), in the paper referred to, has brought forward more complete and convincing evidence of the same kind in *Lasiocampa quercus* L. Prof. Heslop Harrison[6]) has also observed the unwillingness of bred Saturniid moths of many species to pair, although all "assemble" freely in nature; also once with *Orgyia antiqua* L., and *Parasemia plantaginis* Hübn.

C. Physiological Barriers.

It is possible that infertility of the first pairings between closely related sexes, and the prepotency of more distant crosses when two successive pairings have occurred, may play a part in the prevention of inbreeding, but specially directed observations on a large scale are required. The following note by the late Dr. T. A. Chapman[7]), F. R. S., bears upon the first of these suggestions, and probably upon the second. He found that the males and females of a large brood of *Acronycta strigosa* F. paired readily and frequently together, but no eggs were laid. He then got some captured males, which paired with equal readiness with the bred females, and as a result obtained plenty of fertile eggs.

It is possible that preferential mating may co-operate with these principles. Thus Mr. Pearman informs me that the males of *Psocidae* "pay court to the females, and the latter appear to exercise choice in their selection of partners. I have observed on many occasions among captive individuals reluctance by the females to pair with males of their own blood."

Dr. J. W. Munro[8]) has also recorded that males of the Blowfly *Calliphora erythrocephala* Mg. do not normally pair with females of the same brood, but wait for later emerging females. He calls attention to the

[1]) *Parasitology*, vol. 9, 1916—17, pp. 228, 232, 233, 335, 256.
[2]) *Proc. Ent. Soc. Lond.*, Vol. II, 1927, pp. 75—82.
[3]) *Ibid.*, Vol. II, 1927, p. 82.
[4]) *Ibid.*, Vol. III, 1928, p. 37.
[5]) *Ibid.*, Vol. II, 1927, p. 76.
[6]) *Ibid.*, Vol. III, 1928, p. 19.
[7]) *Ibid.*, 1903 (1904), p. cxi, note.
[8]) *Proc. Ent. Soc. Lond.*, Vol. III, 1928, p. 34.

fact that this observation was originally made by the late Mr. B. T. Lowne in his work on the Blowfly.

It is necessary to emphasise, in concluding this preliminary sketch of a vast subject, that there is strong evidence to prove that the evil effects of inbreeding are not an essential physiological necessity. Thus, among plants, in which the adaptations for cross-fertilization are so elaborate and widespread, regular self-fertilization is common. Prof. A. G. Tansley, F. R. S., has kindly selected a few examples from our common British species: —

" The great majority of inconspicuous flowers are regularly self-fertilized. A common example is the Chickweed *(Stellaria media,* Vill.). Others are the small-flowered Veronicas *(V. hederifolia* L., *V. agrestis* L., etc.). I cite them because they contrast well with conspicuous normally cross-pollinated allies, such as *Stellaria holostea* L. (Stitchwort), *Veronica chamaedrys* L. (Germander Speedwell), etc. The Garden Pea *(Pisum sativum* L.) is a good example of a conspicuous flower which is always self-pollinated [1]).

Similarly in insects Dr. P. A. Buxton, in the following passage from a letter, has reminded me that "Macfie at Liverpool raised *Stegomyia* from a single pair and kept it going several years. You may reckon a generation to take between 2 and 4 weeks. We have a stock of a Reduviid bug *(Rhodrius prolixus)* which has been in the Laboratory perhaps 8—10 years, each generation lasting 3—4 months." Even if these Reduviids started from a number of unrelated insects, a possibility suggested by Mr. Buxton, the inbreeding must now be excessive. The parthenogenetic breeding of *Phasmidae* is well known to have continued in captivity for many generations, the offspring being female, with very rarely an occasional male [2]). Even among the ants, a group in which special adaptations for cross-breeding have been described under B. (1) on p. 584, Mr. Donisthorpe has called my attention to species in which pairing takes place between members of the same community, within the nest.

These are only a few examples of a well-known fact, but they are sufficient to shew that close inbreeding is not of necessity physiologically injurious. Why then should it have become so in the vast majority of plants, and probably of animals, and why should so many and such varied adaptations have arisen to hinder or prevent inbreeding? I can only fall back upon a suggestion made in 1904, a suggestion which, in setting forth the advantage in evolution of sexual over asexual reproduction, implies throughout a sexual reproduction by cross-breeding as opposed to inbreeding. It is obvious that closely inbred species [3]) must sooner or later lose the great, and, in the end, essential advantages described in the following passage: —

---

[1]) Of less significance for the present purpose are the "very large number of flowers, including very conspicuous ones, e. g. the common field buttercups, which are capable of self-fertilization, and are in fact regularly self-fertilized in the absence of insect visits, as a result for example of dull cold weather".

[2]) "A Naturalist in Borneo" by the late R. W. C. Shelford, London, 1916, pp. 154, 155.

[3]) Proc. Ent. Soc. Lond., 1903 (1904), p. cxvi.

"By inter-breeding the favourable variations arising in one direction are combined with others arising in different directions; by the kaleidoscopic changes produced by inter-breeding more varied results are presented for selection, and the beneficial qualities arising in one part of the mass may quickly become the heritage of the whole [1]). By inter-breeding excessive spontaneous variation is checked, and the whole community of the species advances surely and with stability into adjustment with the progressive changes of the environment."

[1]) The rapidity with which variations can be passed on over considerable areas is seen in the rapid spread southward of the dark form *doubledayaria* Mill. of *Amphidasys betularia* L., after its sudden predominance in the northern manufacturing districts. This variety, entirely unknown in the Oxford and Reading districts in my boyhood, is now quite common. The appearance of single examples of the *dorippus* Klug form of *Danaida chrysippus* L. in South Africa and Ceylon is to be reasonably explained by transference through inter-breeding from more northern localities in East Africa and the West Coast of India.

Contribution to the Interpretation of the Cephalic Segments of Arthropoda.

Dr. Kai L. Henriksen, Zoological Museum, Copenhagen, Denmark.

In a previous paper the author stated that the head of the Trilobites consisted of 7 segments, the last of which became incorporated in the head at a later ontogenetic stage than the other segments which form the primary head capsule, and — as in shape it agrees with the following, free, thoracic segments as to median spines and other sculpture, and overlaps the next segment, just as do the thoracic segments — must be termed a typical maxilliped segment. The appendages belonging to this segment (= lst thoracopod), however, have not altered in shape, which was not to be expected either, as even the real mouth parts have remained unaltered, leg-like.

As Trilobites are very generalized Arthropods, it is interesting to find out whether a maxilliped segment also belongs to the head of other Arthropods, and whether its pair of appendages are transformed into real maxillipeds.

In Crustaceans, Myriopods and Insects the mandibles are always easily recognizable, as they are shaped like jaws, and the pair representing the maxillipeds is then to be reckoned the 3d pair of appendages behind them, as maxillulae and maxillae are inserted in between them. If therefore maxillulae and maxillae can be recognized, the lst thoracopods must be the next appendages.

CRUSTACEA. — In the groups occurring as the oldest in the geological strata (Branchiopoda, Ostracoda, Leptostraca) no maxilliped or maxilliped segment is developed at all, or the genera may be arranged in a file from such forms without to forms with mxp and mxp-segment. This latter is also the case in the generalized Malacostracan group Syncarida. In all the other Malacostracan groups (Euphausiacea however excluded) as well as in Copepoda the lst thoracic segment has fused into the head as a real maxilliped segment and its appendages are specialized into real maxillipeds (with endite lobes or otherwise). In the Decapoda, showing 3 pairs of maxillipeds, it is quite obvious that mxp_1 is the real mxp, while mxp_2 and mxp_3 are much less specialized (no endite lobes, etc.).

As it is the features of Malacostraca which have given rise to the terms antennula, antenna, mandible, maxillula, maxilla, maxilliped, a few words of the typical shape will be of value for the identification of the appendages in question of the insects. As pointed out by H. J. Han-

sen the sympod of the maxillula has typically an endite from the lst and one from the 3d joint, the sympod of the maxilla endites from the 2d and 3d joints (but not from the lst), and the maxillipeds may meet or even fuse together along the midline (Amphipoda, Isopoda, Cumacea).

MYRIOPODA. — As to maxillulae and maxillae, the Myriopods naturally divide into 2 groups, viz. the one having both pairs developed (Symphyla, Chilopoda), and the other with the maxillulae missing and only the maxillae present (Pauropoda, Diplopoda — in the latter order perhaps also some sternal parts of the postoral segments, "hypopharynx", are included). The same grouping of the 4 orders is also seen as to the first body segment. In Symphyla and Chilopoda real maxillipeds are present, being in the latter order the big poison claws, while the homologous limbs are rudimentary or missing in Pauropoda and Diplopoda. The mxp-segment itself, however, can always be recognized.

INSECTA. — The common interpretation of "maxillae" and "labium" of insects is that they correspond to maxillulae and maxillae of Crustaceans respectively. H. J. Hansen, however, has called attention to the important fact that the "maxillae" of insects quite agree in shape with the maxillae (mx_2) of Malacostracans, as they have endites, lacinia and galea, from the 2d and 3d joints (stipes and palpiger), and none from the lst joint (cardo), and not with the maxillulae. Likewise the "labium" shows an extreme conformity in shape (endites fusing along the midline, etc.) with the maxillipeds of Isopods and Cumaceans, so that submentum represents cardines, mentum stipites, and prementum the palpigers. The tergum of the labial segment is incorporated in the head (according to the embryological investigations of Holmgren) and anteriorly outlined on the head by an occipital suture (as pointed out by Snodgrass in a recently issued paper). The sternum is in Dermaptera rather large, being the sclerite termed gula (in beetles gula, however, is quite another thing, having nothing to do with the sternum), which in many generalized insects (Blatta, Mantis, Zorotypus, Plecoptera, etc.) may be present as a reduced unpair ventral "cervical sclerite". The pleurae are the 2 pairs of lateral "cervical sclerites" which are rather constantly met with in insects, and which may be smaller or larger (f. inst. large in Blatta). It is certain that some of the cervical sclerites occurring in insects may be interpreted as apotoms from the prothorax, or as intersegmental chitinizations, but the 2 in question, to which the muscles are attached to the head, cannot be interpreted in that way, nor as belonging to a separate intermediate segment (microthorax), as neither embryology, nor anatomical features (ganglia, etc.), nor paleontology show any trace of such a 4th thoracical segment. Without any doubt they represent the pleurae of the labial segment, which in the generalized insects with discernible gula is adjacent to this latter, and further also usually adjoins the lower part of the occipital rim (the labial tergum).

If this interpretation (maxillae $= mx_2$, labium $= mxp$) is correct, the real maxillulae (mx_1) must be sought for, and I agree with Hansen in

considering the side parts of hypopharynx, which have commonly been termed superlinguae or (but then erroneously) paragnathes, as the real maxillulae. Like Hansen I must lay stress upon the fact that in Machilis these superlinguae do not emerge from the projecting hypopharynx lobe, but *articulate* with the mouth floor lateral to it (and the shape of them allows an interpretation of a little palp, and tendency to fission in 2 endite lobes). I must also refer to the features of Japyx and Collembola, described by Hansen. In Japyx the socalled paraglossae represent the lacinia of Mx_1, and what investigators previous to Hansen have termed galea and palpus of the maxillae are really galea and palpus, but belong to the Mx_1, as they are, through firm chitine, connected with the "paraglossae". In Collembola there have also been described "paraglossae" and palp of the maxillae — in that case representing the entire maxillula (viz. lacinia and galea — the palp missing). They are fixed anteriorly to the maxillae (mx_2) and at the base of the hypopharyngeal tongue, articulating with the mouth floor itself, thus showing their separate nature from each of these parts. — Miss Evans, later on, has followed the increasing reduction of the "superlinguae" within the insect system and the increasing fusion of them with the hypopharynx-outgrowth, and, putting aside some uncertain cases among the higher insects, it must be granted that the superlinguae are homologous *inter se* within the whole file of insects (just as is the (proper) hypopharynx). And if in Apterygota they really represent a pair of appendages this must be the case also in the higher groups. Folsom further stated the separate "Anlage" of hypopharynx and "paragnathes" (superlinguae) in the embryo of the spring-tail *Anurida*, and Bengtsson has investigated the development of the mouthparts of the crane-fly *Phalacrocera*. Also Bengtsson recognized the maxillulae and stated that in the larvae the maxillulae still possess their separate nerves, which, however, seem to vary to a good extent ("bei einigen Individuen sind sie gut entwickelt, bei anderen bedeutend schwächer, und ich bin nicht sicher, ob sie nicht vielleicht zuweilen ganz fehlen können. Ihre Entwicklung gibt also ein Bild des allgemeinen Gesetzes für sog. rudimentäre Organe"). Some recent investigators do certainly not agree with the authors mentioned above in considering the superlinguae as the maxillulae, as they will only homologize them with the paragnathes, i. e. outgrowths from the mouth floor, and reference has been made to the fact that mandibles and "superlinguae" occur on the same somite during the embryological development of the spring-tail *Tomocerus* (Hoffmann). But the embryological investigations by Holmgren and Heymons make it most probable that the embryonic hypopharynx represents the common sternal part of more than one postoral segment, and it looks to me quite natural that the rudimentary maxillulae — which have a sternum in common with the mandibles — may appear near or even medially to the mandibles. Principally I must maintain that sclerites and soft-skinned membranes in the adult stage are more to be relied upon than the embryonic characters, which can never give the concordance in details, and which may often be distorted.

ARACHNIDA. — According to the common view, head and thorax have fused into a "cephalothorax" in such a way that the 6 pairs

of limbs attached to it have been very differently interpreted, but always so that the posterior ones are considered homologous with some thoracical legs of the insects. Only Lankester has had the right view, and arguing from quite another starting point I must confirm his view. When a comparison is made of a series of Paleozoic Arthropoda, viz. Trilobites — Aglaspids — Hemiaspids — Belinurids, to which series we also add the Triassic-recent genus *Limulus*, as to the body (seen from above) and the limbs, no doubt at all can appear as to the homology of the head of Trilobites with the "cephalothorax" of the other groups. Also the segmentation of the "cephalothorax" of the "trilobitiform larva" of *Limulus* is — even in detail — quite like that of the head of a Trilobite. Thus: the "cephalothorax" of *Limulus* is the real head, and the limbs beneath it must be the head appendages.

Further, that *Limulus* and *Eurypterus* are very closely related is commonly accepted, though one is not the ancestor of the other, and a simple comparison of the body and limbs (as published, f. inst., by Versluys-Demoll) shows a striking agreement. And from the Eurypterids the transition to the Scorpions is easily established (the Eurypterid *Eusarcus* f. inst. is very much scorpion-like in appearance). The "cephalothorax" of a scorpion is therefore the head, while all that is situated behind this part, is not "abdomen", but the entire "trunc". As there can be no doubt that the file of limbs is homlogous in all Arachnids (no author has thought of denying it), it is a matter of course that we must look upon the body of all Arachnids not as divided into cephalothorax and abdomen, but into head and trunc. The Arachnids thus walk upon their mouth parts.

Even a direct comparison between the limbs of *Limulus* and *Scorpio* gives the same result, as already shown by Lankester.

If, therefore, the head of the Trilobites includes a maxilliped segment (bearing not-transformed maxillipeds), also the Arachnid head must include this segment and the last pair of limbs of Arachnids must then represent mxp. And as this mxp is fixed under the head, anterior to the furrow separating the head from the following (body-) segment, this segment has fused into the head and must be termed — as in the Trilobites — a real mxp-segment, though its appendages possess only in Merostomata a masticatory lobe, while this lobe has disappeared — but secondarily disappeared — in Arachnida vera.

If now we count forwards from the mxp, we recognize that the whole file of limbs is present, representing A_1 A_2 Mdb Mx_1 Mx_2 Mxp. A_2 is thus present, while missing (besides in Insecta and Myriopods) in all the Trilobites whose limbs are known. The Merostomata (and Arachnida), therefore, cannot have taken their origin from such a Trilobite, but from a trilobitiform ancestor possessing also A_2.

This view is supported by other facts: The nephridiae (coxal glands) open in *Limulus*, *Scorpio*, a. o., on the last leg but one, i. e. Mx_2, thus being quite identical with the maxillary glands of Crustaceans (nephridiae and their openings may also in some Arachnids be present on other segments — just as is the case in Crustacean groups).

In Acarina and Ricinulei the larval stages possess only 3 pairs of legs (besides the 2 pairs of "mouth parts"), and a pair of legs is added

during the individual development. As to Ricinulei, H. J. Hansen has stated that it is the 4th pair which comes as the last one (as the 3 anterior pairs possess immovable coxae). This, 4th, pair is thus a mxp, as it becomes added to the head at a later ontogenetic time than the preceding.

Finally the ecdyses: In the Trilobites the most generalized forms, i. e. the *Mesonacidae*, moult through a marginal suture, a splitting line running along the edge of the broad, flat head. In one file of the Trilobite families (*Agnostidae, Trinucleidae*, etc.) the marginal suture is extant as ecdysial splitting line, while in all the other families (*Paradoxidae, Proetidae*, etc.) the splitting of the cuticle takes place along a suture line which only in its foremost part consists of (a part of) the marginal suture, while the lateral parts are secondarily acquired and run on the upper side of the head to the side border of this latter. — Among the Crustaceans the marginal suture also may be met with, f. inst. in *Apus*, one of the oldest Crustacean types still extant. In the other groups this marginal suture may be slightly modified (f. inst. in Conchostraca), or secondarily replaced by other phylogenetically later types of sutures (f. inst. in Cladocera a sagittal furrow, in the Macrourous Decapoda a transverse suture along the hind edge of the carapace, often combined with a sagittal furrow running forwards from it, in Mysidacea a similar transversal furrow combined with lateral furrows running forwards, etc.). In Myriopoda the splitting line is a transversal one just behind the head (but anterior to the maxilliped segment). In Insecta the splitting line is a sagittal one traversing the thoracal segments and continuing forwards upon the head along the epicranial suture, and from the anterior point of this forming a fork (the pair of "frontal sutures", which are only to be considered as secondarily arisen for the purpose of moulting, and of no segmental value). Other ways of ecdysis are met with in the most specialized groups: Dipterous larvae, chrysalids of *Lepidoptera*, etc. But in no insect the old marginal suture is kept — which appears rather natural, if we remember the late origin of the insect group (in the Carboniferous age). Then at last we come to the Arachnid group. In *Limulus* the cuticle splits around the extreme edge of the fore part of the flat animal, and in the *Eurypteridae* ecdysis proceeded in the same manner. In some (recent) specialized Arachnida vera the moulting may take place in quite another manner; in the mite *Tetranychus*, for instance, a transverse split around the body between the 3d and 4th pair of legs. This, however, is certainly secondarily acquired, while the main part of the Arachnida (f. inst. spiders, opilionids, ticks) moult in the same manner as *Limulus*, through a curved line around the "cephalothorax" above the legs, and if we compare this manner with that of the Mesonacids, it is quite clear that it represents the marginal suture, extant here in a group (Arachnida) the origin of which may be traced back even to old paleozoic age — and in itself it is thus a proof that the area which it outlines is really the head.

The result thus is that, with the exception of the Entomostraca occurring in the oldest strata, whose attempts to get maxillipeds have not always obtained a result, the head of all Arthropods includes a maxilliped segment.

(Note: — The matter set forth above will be treated in detail in a paper which will appear in Vidensk. Meddel. Dansk Naturh. Foren., Copenhagen).

Discussion.

G. C. Crampton: In connection with Dr. H's suggestion that the superlinguae of insects may possibly be regarded as true appendages or modified limbs, it should be noted that the superlinguae or paragnaths arise in the mandibular neuromere or segment of the embryo in both insects and Crustacea. They belong, therefore, to the segment having the mandibles as its appendages; and having no neuromere or segment of their own, they cannot be regarded as true appendages or modified limbs.

Permian Entomofauna of North Russia and its Relation to that of Kansas.

Dr. A. B. Martynov, Leningrad, U. S. S. R.

The general character of the Upper Carboniferous Entomofauna of West Europe and North America is comparatively well known. We know the general composition of this fauna, as well as very many representatives of various orders (Palaeodictyoptera, Megasecoptera, Protodonata, Protephemeroidea, Protorthoptera, Blattoidea and Protoblattoidea, as well as some smaller groups). These insects were mostly of large size, with well-developed wings and with rich wing-neuration. Nearly all authors agree that a fauna of such a character (as well as the flora accompanying it) had lived for a long time in a humid tropical or subtropical climate. Many groups — Palaeodictyoptera, Protodonata, Megasecoptera, Protephemeroidea — were probably amphibious, i. e. their young phases lived in water. Holometabolous insects as well as many hemimetabolous orders (Hemiptera, Thysanoptera, Psocoptera, true Odonata, Agnatha and Plecoptera) are entirely absent from the Upper Carboniferous deposits. Our information on the fossil insects of the Permian age — an age of great climatic changes and of great faunal migrations — was very scanty until quite recent times. From Europe are known chiefly Lower Permian insects: true Cockroaches, a few Protoblattoidea and Protorthoptera, and a few other forms. This fauna is doubtless more or less related to some elements of the European Carboniferous fauna, but is in general very poor. From North America only a series of Cockroaches (Dunkar formation) are known. The information is, indeed, very meagre. In 1906 Dr. Sellards discovered a new and rich locality of Lower Permian insects in Kansas, which has furnished a quite new and peculiar fauna. Palaeodictyoptera and Protodonata were few, Megasecoptera lacking altogether, Cockroaches were present, but they were of very small size. Instead of true Protorthoptera, which are absent, a number of small Orthopteroids were found with reduced nervation. I gave to them later the rank of a separate new order: Miomoptera. Instead of Palaeodictyoptera and Megasecoptera true Odonata were found: *Kennedyidae* Till. (Zygoptera) and Agnatha *(Protereismidae)*. Perhaps the most interesting discovery were the Holometabolous insects of the Orders Mecoptera and Protohymenoptera Till. These insects, with the exception of Protodonata and Palaeodictyoptera, are genetically far removed from the Upper Carboniferous and Permian fauna of Europe. They differ also in their habitus, as they were mostly of small size. They represent a distinct fauna which developed, probably for a long time, independently of the fauna of European type, and certainly under different, more temperate, climatic conditions.

Later on Permian insects were found in Australia, and Dr. R. J. Tillyard has made known many of their representatives. This fauna proved to be still more different from the European one, in some features recalling the Kansan fauna. Palaeodictyoptera, Megasecoptera, Protodonata, Protorthoptera and Miomoptera are here quite lacking, but instead of them Homoptera are rather numerous, though different from the Kansan forms. Holometabolous insects are rather well represented in Australia by diverse Mecoptera, Neuroptera, and even by Coleoptera.

It seemed to me very interesting and important to ascertain what kind of fauna existed at that time in the large territory of Russia. Several remains of insects, not more than a dozen, known from various localities of N. E. Russia, were certainly quite insufficient for conclusions. From the information we have of the Permian Reptiles and Stegocephals of N. Russia (from the river N. Dwina) one would suppose that the Permian Entomofauna of N. Russia also must be very different from that of Western Europe. In the summer of 1926 I had an opportunity to collect many fossil insects in the Upper Permian deposits at the village of Tikhiie Gory (= still mts.) on the river Kema, Kazan province, and at the same time M. Edemsky, a geologist of the Museum of the Academy, found a new locality of Permian insects on the river Sojana in the Northern parts of the province of Archangelsk. In both localities remains were taken of no less than 50 species, and many of these insects are in a fine condition of preservation. In July of 1928 I collected additional material at Tikhiie Gory. An examination of these collections, about 75 species, has shown that in the Northeastern parts of European Russia is indeed buried a peculiar fauna differing strongly from the European fauna.

One can discern here three or four elements: the first and most archaic element consists of forms related to some European Upper Carboniferous ones; this element is rather scanty. Here belong: 1) Palaeodictyoptera(?), about 3 species, unfortunately represented by fragments of wings only and therefore not easy to classify exactly; 2) Megasecoptera, one species[1]); 3) Protodonata, one species[2]) (undescribed); 4) Protorthoptera, about 7 species. 13 species, or, with 2 Cockroaches from Kargala, Orenburg province, altogether 15 species, which is about $^1/_5$ of the total list. Megasecoptera are represented by a new family *Kulojidae*[1]), allied to the European *Mischopteridae*. The Protorthoptera are represented by new genera more or less allied to some European forms of *Oedischiidae* and *Stenaropodidae*, or even by new families allied to the European *Caloneuridae* and *Palaeocixiidae*. Almost all these forms are of rather large size, though somewhat smaller than their Upper Carboniferous relatives.

The remaining $^4/_5$ of our fauna reveal quite a different character. Of special interest are peculiar small forms with reduced neuration, the *Palaeomantidae* Handl. (emend.), about 10 species of this family being found in the two localities, belonging to 4 genera. A careful examination of their wings revealed the interesting fact that the nervation is very similar to that of the *Delopteridae* and, partly, *Lecoridae* described by Sellards from the Lower Permian of Kansas. Some forms collected this year at Tikhiie Gory and not yet described appear to be closely allied or

[1]) and [2]) cf. note at end of this article.

to belong to the *Lecoriidae* Sell. or *Lemmatophoridae* Sell. One form seems to belong to the *Liomopteridae* Sell. All these families I have separated (1927) from the Protorthoptera as a new Order Miomoptera, not closely related either to Protoblattoidea or to Protorthoptera. The Miomoptera are an extinct order, but the recent Embiodea can be considered as an offshoot from the stem of this order. It is of importance to note that till now Miomoptera have only been found in the Permian of Kansas and N. Russia. The affinity of the faunae of these districts is indicated also by some other groups. In both Russian localities were found, in 1926 and 1928, remains of wings of Mecoptera belonging to no less than 4 genera with 7 or 8 species. These forms are allied or even belong to the Kansan *Permopanorpidae* Till. The genus *Dinopsocus* Mart., from the Sojana river, is related to the Kansan suborder Permopsocida Till. As to our Protoblattoidea, *Sindonopsis* Mart., with 2 species, is somewhat allied to the Kansan *Sindon* Sell., and *Epimastax* from Tikhiie Gory to some Upper Carboniferous American forms, such as *Cacurgus*, *Spilomastax* and *Glaphyrophlebia.* Two Cockroaches found this year at Tikhiie Gory have not yet been sufficiently studied; they are small and apparently resemble some Kansan forms. Our Agnatha, at least *Loxophlebia apicalis* from Tikhiie Gory, belong to the *Protereismidae.* Lastly, *Hypoperla gracilis* Mart. reminds one somewhat of the North American *Spanioderidae.* In all, this second faunal group contains from 28 to 31 species, or almost $^2/_5$ of the total list. The greatest part of this fauna differs strongly from the first group not only genetically, but also in the whole habitus, as almost all these insects are of small size. This feature is also characteristic of the Kansan Permian fauna and shows that the ancestors of these faunae developed under the conditions of a more temperate, or perhaps partly cold, climate.

All the remaining forms belong to the orders unknown from the Upper Carboniferous fauna of the European type, but the affinities of these forms are different from those of the second group. The greatest part of the element under discussion is formed by Homoptera of the families *Prosbolidae, Scytinopteridae,* and *Cixiidae.* The *Prosbolidae* are represented in North Russia by 3 genera: *Prosbole* Handl. (3 species), *Sojanoneura* Mart. (4 species, in both localities) and *Permocicada* Mart. (2 or 3 species from Tikhiie Gory). The tegmina in *Sojanoneura* are interesting by the presence of two apparently independent subcostals, the posterior one running along R. The dividing line is distinct only in *Prosbole* and *Sojanoneura;* this line being wanting in *Permocicada.* Besides N. Russia, *Prosbolidae* are known from the Permian of Australia, whence Tillyard has described 3 genera. Moreover, I consider the genera *Orthoscytina* Till., with 10 species, *Homaloscytina* Till., with one species, and *Elliptoscatia* Till., with one species, classified by this author with the *Scytinopteridae,* also to belong to the *Prosbolidae.* This family therefore appears to be better represented in Australia than in N. Russia. The *Scytinopteridae* are also found in the Permian of Australia, but the Australian Permian genera are rather far distant from the N. Russian ones; only in the Triassic of Australia appear some forms which come closer to the Russian genus *Scytinoptera.* The *Cixiidae* also are only known from the Triassic of Australia. Of 3 North Russian Neuroptera *Palaemerobius proavitus* Mart. represents a distinct genus which much resembles our re-

cent *Hemerobiidae; Eopsychopsis* Mart. (Tikhiie Gory) belongs to the *Prohemerobiidae* and apparently is allied to the Australian triassic *Protopsychopsis* Till.; and *Sialidopsis* Zalessky, separated as a new family on account of the nervation, is very similar to some *Permithonidae* from the Permian of Australia and, I think, may even belong to this very family. In the Permian of Australia Neuroptera are more numerous and diverse than in N. Russia. Considering all facts adduced it is justified to suppose that the ancestors of *Sialidopsis,* at least, migrated during the Permian from Australia into Russia, or more generally stated, from the Gondwana Continent, as did some plants and reptiles. This hypothesis, however, seems to be rather unsuitable in the case of the *Scyptinopteridae,* as the forms, more or less resembling our *Scytinoptera,* as well as the *Cixiidae,* appear later in Australia, in the Triassic. The Russian *Prosbolidae* are also very different from the Australian ones and even if they have had ancestors in common with the latter, they must have independently developed in the Northern lands for a long time.

Megaloptera, found at Tikhiie Gory, were not known before from the Palaeozoic deposits. It is to be noted that the wings in our genus *Permosialis* are not very archaic; in the simplification of their nervation they are even more advanced than the recent *Sialidae* (s. str.) and constitute a side-branch of the stem of true *Sialidae.*

The Upper Permian Entomofauna of N. Russia is, as wo have seen, a mixture of 4 main elements. The first is European and represents the remains of the thermophilous European Upper Carboniferous fauna. In its place, under the conditions of a changed, somewhat colder and more arid climate, appear in the Permian some immigrants from other centres of evolution. Of the greatest importance was the centre — or zone of lands with temperate and partly cold climate which grouped around the North Pole of the Permian age. According to the theory of Wegener and Köppen the North Pole at that time was situated in the region of the recent North Pacific. Some elements of this faunal zone reached Kansas as early as the the Lower Permian or even earlier; other elements, partly allied to the Kansan fauna (Miomoptera, Mecoptera, Psocoptera and some others), partly more distinct and independent of the latter (Megaloptera, *Scytinopteridae,* perhaps the North Russian *Prosbolidae*) migrated westwards and reached North-European Russia in the Upper Permian or somewhat before. The last mentioned groups, as stated above, reveal a certain, though not very close, affinity with or similarity to some Australian (or Gondwanian) Permian groups; but I think that this similarity (bipolarity) should be explained rather as the result of a long parallel evolution of analogous elements under similar climatic conditions (Northern and Southern temperate zones). Both these elements have probably developed from some common, but very archaic, Upper Carboniferous ancestors. Lastly, a few of the North Russian insects, i. e. their immediate ancestors, for instance the genus *Sialidopsis,* can be considered with some degree of certainty as immigrants from the Australian Permian fauna.

Discussion.

Dr. Tillyard said that he had listened to the paper with great interest and wished to congratulate Dr. Martynov on his fine work.

He would like to draw the attention of the audience to the fact that we now had three very fine Permian fossil insect beds, one being the Lower Permian of Kansas, which was only a little newer than the Upper Carboniferous, another the Permian of North Russia, apparently considerably newer than the Kansan, and a third the Upper Permian of Belmott and Warner's Bay, Australia, which was very high up in the Upper Permian and only a few hundred feet vertically below the beginnings of the Lower Trias. In these three faunas a rich insect life was disclosed and we could actually see Orders in the making, so that it was difficult for a worker to indicate where an old Order ended and a modern Order began. He did not think Dr. Martynov's Order Miomoptera could stand, but he could not blame him for making it when he himself had made others also. The value of these Permian faunas for the understanding of the evolution of the Pterygote insects was immense, and it was to be hoped that many more specimens would yet be brought to light, as over six thousand had already been collected in Kansas, and many thousands were awaiting the first man who would take the trouble to go and collect them.

Additional Note. — I now believe that *Kuloja expansa* probably belongs to the Protohymenoptera. The single species of Protodonata proves to be somewhat allied to the Kansan genus *Calvertiella* Till. — A. Martynov, 1929.

The Role of Function in Taxonomy and its Relationship to the Genitalia in Insects.

F. Muir, Hawaiian Sugar Planters' Experiment Station, Honolulu.

The taxonomic divisions in the animal and plant kingdoms are founded upon morphological characters, but the chief ones represent functional differences, although they are described in terms of morphology. As we descend to the lesser divisions, the function is less apparent, and morphology appears as the chief criterion. While the broader classifications are comparatively natural, the minor divisions are much less so and are open to considerable criticism. If we could carry the idea of function into these latter, I believe it would be greatly to the advantage of taxonomy.

There is an opposite school to this which contends that functionless characters, or those with little function, are the more suitable for taxonomic use, but this, I believe, is not correct.

If we consider the chief taxonomic divisions in insects — such as Apterygogenea and Pterygogenea; Ametabola, Hemimetabola and Metabola; Menognatha, Metagnatha and Menorhyncha; — we find that function is the basic factor. Whether flight be by one or by two pairs of wings, whether the chief function is performed by the front or hind pair, whether the front pair act as protectors or covers, all represent function. The different methods of sucking, as displayed by Hemiptera and Diptera as well as others, also can be stated in terms of function. If not all, then much of the differences in venation must be due to function. Platygenesis and stenogenesis with the associated increase and decrease of venation undoubtedly are.

The genitalia of insects are as vital to the race as the mouthparts are to the individual. The fact that they must have functioned successfully all down the ages might lead one to conclude that they must have been perfected and standardized early in the phylum and that little change has taken place. We find the facts quite to the contrary, for not only are specific differences of details very great, but the mechanical principles upon which they are constructed differ fundamentally in the same order, especially in the male. These organs have had to respond to all the changes of form, habits and habitats of the organism, as well as to physiological differences, and it is our duty to interpret them as adaptations to function, even if we describe them in terms of morphology, the same as we have done with the mouthparts. If we do this, I believe we shall add greatly to the strength of the foundations of our taxonomic edifice and add enormously to the superstructure.

It is impossible to make a survey of the various orders, as the time at my disposal is too short, and the knowledge at present at our disposal is far too inadequate. I shall therefore only draw a few examples from the two orders with which I am most familiar, viz., Hemiptera and Coleoptera, and these will mostly relate to the male.

In the male Hemipteron the ninth abdominal segment (perhaps along with other elements) forms a distinct (more or less) ring segment (the pygofer) enclosing the genital area. From the dorsal or posterior portion of this genital area arise the small tenth and eleventh segments which form the anal segment. From the center of the genital area arises the aedeagus, and nearby, on each side, arise the genital styles (claspers or parameres) which are always independent or semi-independent of the aedeagus. In certain of the Homoptera the ventral portion of the pygofer is formed of two plate-like appendages more or less amalgamated together, a condition not recognized in other orders. This type of male genitalia is common to other orders, i. e. Lepidoptera and Trichoptera, although all the details may not be strictly homologous.

With a few exceptions, such as those specialized to live underground or under bark, the Hemiptera live a free life, a few in water, but the vast majority on plants, and the type of male genitalia prevalent among them can be called exposed. Two lines of modifications have taken place, one in the Heteroptera and the other in the Homoptera. In the latter the pygofer is large and connected with the eighth abdominal segment by a very short membrane or is, more or less, amalgamated to it, so that there is little or no provision for the pygofer to twist on the central axis. During copulation the male rides the female; where the complete ovipositor is present, the gonopore is some distance from the apex of the female abdomen and the male has to pass his abdomen down the side of the female to reach it (false male vertical pose); but when the ovipositor is small or rudimentary, the male can pass his abdomen over the apex of the female abdomen (male vertical pose). The genital styles are used as claspers, especially in the case of male vertical pose, where the anal segment is also developed into a clasping organ opposed to the genital styles. The female often has modifications adapted to the male claspers. As no provision exists for the pygofer to twist on its axis, and the claspers hold the female, the male cannot leave the back of the female to take up an end to end position; if he releases her from his hold with his legs, he remains attached by his claspers at a greater or lesser angle to the female. In the Homoptera there is no large, complex, internal sac, but in some there is a simple internal sac or unmodified portion of the ejaculatory duct which is everted during copulation and forms the chief intromittant organ.

These adaptations, I believe, are bound up with the habits of the insects. In the Homoptera copulation does not occupy very much time and during that time there is normally very little movement; if disturbed, the insects move off by the female giving a sudden spring, landing somewhere nearby. This makes the presence of a large internal sac unnecessary and the presence of adequate clasping organs necessary, and so no provision has been developed for the twist and an end to end position.

Among the Homoptera there are two chief types. In one, the more numerous, the aedeagus is simple, more or less cylindrical or subcylindrical, and it is often composed of two more or less distinct portions, a basal portion or periandrium and a distal portion or penis, and there appears to be an evertable sac in the majority. In the other, or less numerous, type, which is composed of certain of the Fulgoroidea, the basal portion (periandrium) of the aedeagus is funnel shape and the aedeagus is pulled into it and so arises from the bottom of the funnel. There appears to be no evertable sac, but certain structures are often present inside the penis. At present we know far too little about the functioning of these two types, but from their fundamental structural differences we can deduce that they function very differently. In most of the species with a funnel shape periandrium the females have incomplete ovipositors and in the majority of cases the complete ovipositor is associated with the cylindrical type of periandrium; but there are exceptions which prevent us drawing wide generalizations.

Turning to the Heteroptera we find a fundamental difference. In these, with a few exceptions, the ninth abdominal segment or pygofer is attached to the eighth by a large membrane, and the eighth is attached to the seventh by a large membrane, the eighth often being small and cup-shape to fit over the base of the ninth. This makes ample provision for the pygofer to twist on its longitudinal axis some 180° or more. In the vast majority of species the internal sac is large and often complex, and as when inflated during copulation it cannot be withdrawn, it acts in place of claspers. The genital styles are comparatively small and not effective as claspers, and the anal segment is seldom, if ever, employed to that end. The method of locomotion of the Heteroptera is by flight or by walking, never, or but very rarely, by jumping, a method so characteristic of the Homoptera as to earn many of them the names of leaf hoppers, plant hoppers, and sharp shooters. The time occupied by Heteroptera in copulation is generally long; the male rides the female (male vertical pose), but later takes up an end to end position. If disturbed the female drags the male away or at times takes a short lumbering flight, the distended internal sac being the chief mechanical means of attachment. There are many interesting departures in procedure which must be related to the habits of the insects, such as the side to side position taken by some of the water bugs, which, no doubt, is due to the necessity of moving about rapidly on the water, which would be difficult in an end to end position.

The highly specialized *Coccidae,* with their sedentary habits and reduced size, present interesting developments. Here we often find the pygofer practically absent and the genital styles greatly reduced.

If we now compare the male genitalia of the Hemiptera with those of the Coleoptera, we shall find certain fundamental differences. In the Coleoptera the last three or four segments of the abdomen are withdrawn into the preceding segment when at rest, and the apex of the abdomen is formed by the meeting together of the posterior margins of the seventh or eighth sternites and tergites. Thus the genitalia are hidden when at rest. There is no ring segment or pygofer and the aedeagus is formed by the median lobe or penis in association with the lateral lobes or parameres.

In most species there is a basal sclerite or basal plate to which the lateral lobes, and often the median lobe, are attached or articulated. This aedeagus is attached to the body wall by a large membrane which allows it to twist on its longitudinal axis 180° or more. In the vast majority of cases there is a large evertable sac, the internal sac, which is often very large and complex, and in some cases bears large armatures. The male vertical position is the common one, and copulation generally takes considerable time, so that the male as a rule takes up an end to end position. When disturbed the female generally crawls away, dragging the male behind her; more uncommonly they fly a short distance. Here again the large internal sac acts as a coupling organ, and the lateral lobes are not used as claspers.

The three families *Dytiscidae, Haliplidae* and *Pelobiidae* differ fundamentally from all other Coleoptera in the shape of the median lobe, which is funnel-shape and has no evertable sac. The function of this type is quite distinct, as the organ is used to hold a large spermatophore which opens at the apex and discharges the sperm into the female.

Apart from these three families there are several distinct types of the aedeagus, functioning along quite different lines and built upon fundamentally distinct principles. What I consider to be the most generalized form is the trilobe, without a basal piece, found in the Caraboidea; here the lateral lobes are attached to the base of the median lobe. In the *Cicindelidae* the basal piece is represented by a small sclerite. In the *Scarabaeidae* the basal piece is greatly developed, the median lobe strongly reduced and the internal sac large and often very complex. In the *Tenebrionidae* there is a similar line of evolution, but the internal sac is simple; in some cases the median lobe is reduced to a small membrane. In the *Staphylinidae* the median lobe is developed into a bulb with a very small median foramen and a large median orifice, the dorsal and ventral walls being chitinous with membraneous area between; by a contraction of muscles the capacity of the bulb is reduced, and blood pressure ejects the internal sac. This is carried to a wonderful state of perfection in some species (i. e. *Xantholinus* spp.) In *Pinophilus rectus* we find a spring-like flagellum and the mechanism is very different, as the sac is not evaginated.

In the *Phytophaga* we have a type in which the tegmen is reduced to a ring-like structure, with or without lateral lobes and with a ventral apodeme; the ring is often reduced to a Y-shape structure and in some cases to a small rod. The median lobe is long, cylindrical and more or less slender, the internal sac being large. It is attached to the ring-like tegmen by a large membrane which allows of considerable play through the ring.

It is interesting to note that in the *Scarabaeidae* there is often a muscular bulb which acts in a manner similar to the bulbous median lobe of the *Staphylinidae.*

We cannot here go into the details of the modifications of these types. From the primitive type found in the *Carabidae* it is possible to conceive of the evolution of the other types. That they are adaptations to the form, habits and habitats of the insects is most probable, but until we know more about the functioning of these organs during copulation it is of little use to speculate along these lines. The hidden form of genitalia that we

find in the Coleoptera may be an adaptation to the original cryptic habits of the Order; it is probable that the early forms hid under bark, among rotten wood, under dead leaves and in soil, like so many do today, and in such habitats locomotion would be less impeded and the delicate organs much better protected by being withdrawn into the preceding segments. It is interesting to note that the *Blattidae*, also leading cryptic lives, have evolved along the same line.

Among the Coleoptera the females are without an ovipositor homologous to that found in Hemiptera. In most species there is no trace of such an organ, but in a few forms that lay their eggs in the tissues of living plants there is a re-adaptation to that end.

It would be of interest to compare the genitalia of other Orders, especially the Diptera, but time will not allow of it. The study of the function of these will clear up points in the taxonomy at present obscure.

The consideration of these subjects leads to the old question as to which came first, form or function. Without being able to go into the argument at the present time I must express my conviction that function, or the urge to function, mut have come before the development of a complex organ could have taken place. If form arose first it would be useless without the urge to function.

The factors of evolution are many and those that produce the small characters peculiar to varieties and even species, which are the material we have to use in our breeding experiments, are likely to be very different from those which produce the complicated mechanisms, anatomical, morphological and physiological, which are vital to the organism. It is because the genitalia are of such vital importance to the organism, and are so complicated in structure and function, that I believe they will be of great importance to taxonomy when we understand their function as well as their form.

If the consideration of function is of value to taxonomy, it is absolutely essential to morphology. In reading the works of some of our most active morphologists one does not get the impression that they are really dealing with organisms that lived and worked.

The Insect Carrier of *Onchocerca volvulus* in Liberia.

Dr. J. Bequaert, Department of Tropical Medicine,
Harvard University Medical School, Boston, Mass.

Patrick Manson's discovery in 1877 of a mosquito's rôle as the obligate carrier of a human blood-worm may truly be called epoch-making, for it was the starting point of modern Medical and Veterinary Entomology. Several other helminth parasites have since been shown to need some insect host in order to complete their life-cycle. One of the last to be added to the list is the African parasite of man, *Onchocerca volvulus* (Leuck.)

This worm is a strictly human parasite, the adult living in a subcutaneous fibroma, or tumor of fibrous connective tissue. The larvae, or microfilariae, also are found in this tumor; but they eventually wander to the derm of the skin, where their presence has been claimed to cause the symptoms known as filarial itch. *Onchocerca volvulus* occurs throughout the densely forested, humid parts of Equatorial Africa, and is almost restricted to the West African Subregion of the Ethiopian Region. Several cases of infection with this parasite were observed among the natives in the interior of Liberia by the Harvard African Expedition (1926—1927), of which I was a member.

Insects of some kind have long been suspected as the carriers of O. *volvulus*. E. Brumpt (1904) suggested that tsetse-flies might be involved, but he soon recognized that their rôle was improbable. J. Rodhain and F. van den Branden (1916) attempted in vain to infect the mosquito *Aëdes aegypti* (L.) *(Stegomyia fasciata)* and the tropical bedbug *Cimex hemipterus* (Fabr.) with the microfilariae from the tumors. M. Blanchard and J. Laigret (1924) also carried out unsuccessful experiments with the tick *Ornithodoros moubata* (Murray), with a species of bedbug, the blood-sucking larvae of the Congo floor maggot *Auchmeromyia luteola* (Fabr.), a species of *Simulium*, and leeches. They found, however, that the bite of certain arthropods exerts a definite attraction upon the microfilariae of O. *volvulus* that are scattered in the derm.

The complete larval development of *Onchocerca volvulus* in the insect host was finally elucidated by D. B. Blacklock (1926 and 1927) in Sierra Leone. He showed that the obligate carrier is a species of blackfly *(Simulium)*. After reaching the gut of the insect, the larvae absorbed from the derm wander through the body cavity, migrating later to the muscles of the thorax and eventually to the head of the fly. In the course of these migrations the larvae pass through a series of developmental stages. The

last larval stage gathers in the labium, and on several occasions it was observed breaking spontaneously through the membranous labella at the tip of the labium. Most probably the larvae thus freed enter the skin of man by way of the bite made by the blackfly.

Blacklock's work was carried out with a species of blackfly which he identified as *Simulium damnosum* Theob. In view of the restricted geographical and host distribution of *Onchocerca volvulus*, one might suspect that only one or a few species of the widely distributed genus *Simulium* are able to act as obligate carriers of this parasite. Any observations tending to either support or disprove this surmise will therefore be of value.

The discovery of natives infected with *O. volvulus* in the hinterland of Liberia, naturally turned the attention of Dr. R. P. Strong, Leader of the Harvard Expedition, to the possible carrier. Human cases were studied in the region of Gbanga, a native town about 80 miles from the coast, northeast of Monrovia (approximately in 7° N. and 9° 30' W.). Here Simuliid flies were very abundant in the town, freely biting the natives throughout the day. They were not seen inside closed houses or huts, but were often observed biting under the cover of the open sheds that serve as rest-houses or meeting places in the Liberian villages. A number of the flies caught at Gbanga were dissected. In one case the gut was infected with microfilariae; while in another fly we found larvae of *Onchocerca volvulus*, similar to those figured by Blacklock, in the thoracic muscles.

A careful study of these adult female flies has brought me to the conclusion that the carrier of *O. volvulus* in Liberia is also *Simulium damnosum* Theob. (1903), a species of blackfly originally described from Uganda. Some twenty-five species of Simuliidae have been described thus far from the Ethiopian Region (including the Malagasy Islands). As specialists well know, specific identifications based upon the female sex alone are unusually difficult in this family. Yet I feel reasonably certain of the identification of the Liberian carrier of *O. volvulus*, since I was able to compare it with a series of *S. damnosum* which I collected at the Ripon Falls, near Jinja (Uganda), the type locality of that species.

Simulium damnosum appears to be the most widely distributed of the African blackflies, since it has been reported from Uganda, the Anglo-Egyptian Sudan, Tanganyika Territory, the Belgian Congo, the French Congo, Cameroon, Nigeria, Togo, Liberia, and Sierra Leone. In Liberia it appears to be the most common species, as we have collected it in several localities. It is, however, not the only Simuliid found in that country. In a swiftly running forest stream near Gbanga, numerous larvae and pupae of a *Simulium* were observed mostly fixed to immersed dead and living leaves. The pupae, which will be described and figured in the forthcoming Report of the Harvard African Expedition, bear characteristic respiratory filaments, each consisting of eight slender branches, arising from four dichotomies at different levels of a long common basal stalk. They differ conspicuously from the pupae of *S. damnosum*, as described and figured by H. H. King (1908) and A. W. J. Pomeroy (1920). We have not succeeded in finding the larvae and pupae of *S. damnosum* in Liberia.

Literature.

1. Blacklock, D. B. — 1926. Ann. Trop. Med. Paras., XX, pp. 1—48, Pls. I—IV, and pp. 203—218, Pl. XIX.
2. id. D. B. — 1927. British Med. Journ., I, pp. 129—133.
3. Blanchard, M. and Laigret, J. — 1924. Bull. Soc. Path. Exot. Paris, XVII, pp. 409—417.
4. Brumpt, E. — 1904. Rev. Méd. Hyg. Trop., I, pp. 43—46.
5. King, H. H. — 1908. Third Report Wellcome Research Labor. Khartoum, p. 208, Pl. XXIII, fig. 7.
6. Pomeroy, A. W. J. — 1920. Ann. Mag. Nat. Hist. (9) VI, p. 79, Pl. III, fig. 4.
7. Rodhain, J. and Van den Branden, F. — 1916. Bull. Soc. Path. Exot. Paris, IX, pp. 186—198.
8. Theobald, F. V. — 1903. Reports Sleeping Sickness Comm. Roy. Soc. London, No. III, p. 40.

Pea Aphid Investigations.

J. E. Dudley, Jr., Ed. M. Searls and Alfred Weed,

Bureau of Entomology, U. S. Department of Agriculture *), Washington, D. C.

(With 7 text-figures.)

The production of canning peas in the United States is an agricultural industry which is constantly assuming greater and greater proportions. For the past three years (1925 to 1927) about 200,000 acres have been devoted to this crop, not counting the additional thousands of acres used in growing seed peas. The four states of Wisconsin, New York, Utah and Maryland grow over three-quarters of the nation's canning peas, Wisconsin alone producing over one-half. The canned product for this three year period has averaged over 16,000,000 cases per year, approximately three cans of peas for every person in this country.

The pea aphid (*Illinoia pisi* Kalt.) occurs throughout by far the greater part of the pea growing sections. It occurs in great abundance periodically, but its injury to the pea crop is more closely correlated with plant growth than with the abundance of the insect.

In 1923, following a series of hot, dry seasons which brought about a type of vine growth readily susceptible to aphid injury, the National Canners Association, becoming alarmed at the widespread depredations of this insect, was instrumental in securing an appropriation from the Federal Government which initiated the pea aphid project. Wisconsin was chosen as the location of the central research laboratory on account of her large acreage of peas and repeated damage from the aphid. The laboratory was finally located at Columbus, Wisconsin, where the most generous cooperation has been given by pea canners in general and the Columbus Canning Company in particular.

The great canning industry desired an immediate method to reduce the damage, or, to use the modern commercial expression, it desired **service**. Consequently, efforts were concentrated on working out a direct control or discovering a natural control, or both.

Six seasons of control studies have since yielded results of immense importance to the industry and yet, on account of the intricate relationship of the aphid with the weather and the plant growth, these results must be considered as results for definite years and cannot be expected to hold for the average year.

*) In cooperation with Wisconsin Agricultural Experiment Station.

Gradually increasing biological studies have been carried on in conjunction with the control work, until at the beginning of this season, 1928, the project has become largely an ecological one.

Control and Its Relation to Income.

In Wisconsin over 90% of canning peas are sown with drills. Therefore, the problem of direct control is complicated by mechanical injury to the vines by the passing of spraying, dusting or collecting machines through the fields, and is not as simple as with peas grown in rows.

Direct control experiments have included spraying, dusting, and sweeping by means of an especially designed machine.

Spraying experiments were conducted only in 1923. Of four materials employed, lime sulphur, fish oil soap, lubricating oil emulsion, and nicotine sulfate with fish oil soap, the last material alone proved to be effective in reducing the infestation to the point where an increase in yield might be expected. Several outstanding disadvantages of spraying were most apparent. First, the cumbersome weight of a satisfactory spraying outfit did noticeable damage to the peas and the task of hauling the outfit through soft ground, and even mud, was often met with. Second, the time and experience necessary properly to mix and apply the spray deterred many growers from this method of aphid control. Third, the water supply was frequently both far away and the quality far from satisfactory as a carrier for nicotine and soap. Lastly, it was found that certain dusts gave promise of control equal to or better than that secured with sprays and that they were applied much more easily and quickly and with less mechanical damage to the crop.

Dusting commenced in 1922 and was continued each season until 1927, except in 1925. Results of hundreds of tests must necessarily be summarized quite briefly.

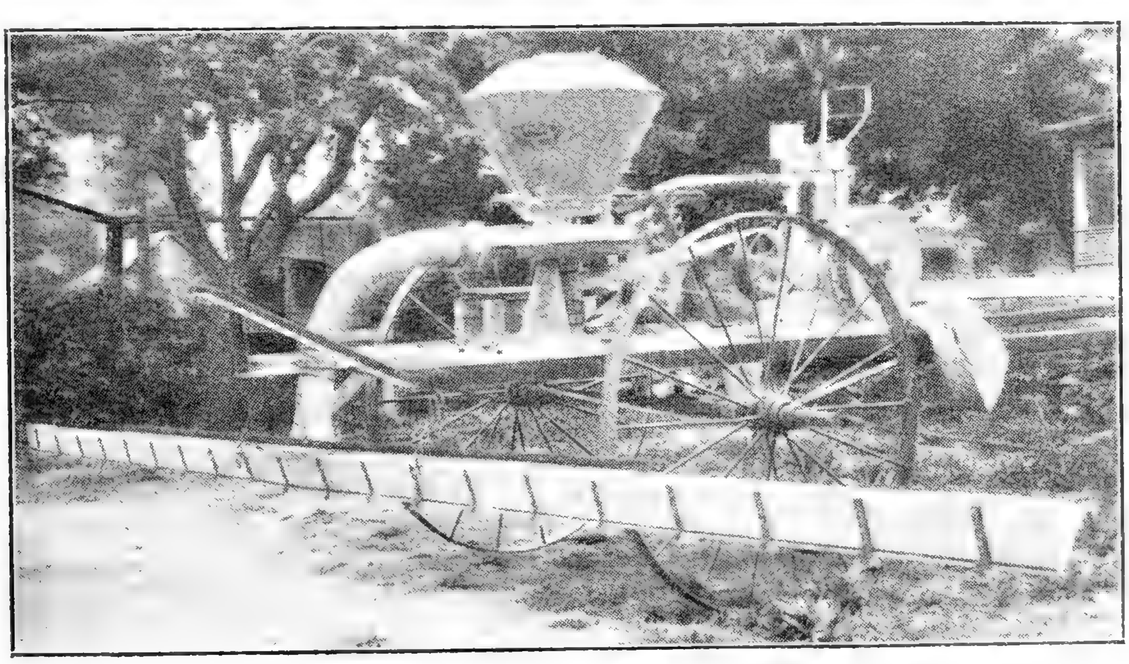


Fig. 1. — Twenty-foot boom for dusting drilled or broadcast crops.
This boom has a continuous and adjustable slit its entire length. It is hung from truck by chains so as to pass over any obstructions without injury to itself.

Both commercial mixed and experimentally prepared dusts were used. These were applied with power dusters, with and without trailers and

drags. Three types of booms were used; first, the standard two-nozzle per row boom, then a y-shaped boom which threw a large volume of dust some distance to right and left, and finally a twenty-foot continuous slit boom, especially designed for dusting drilled or broadcast crops (text-figs. 1 and 2).

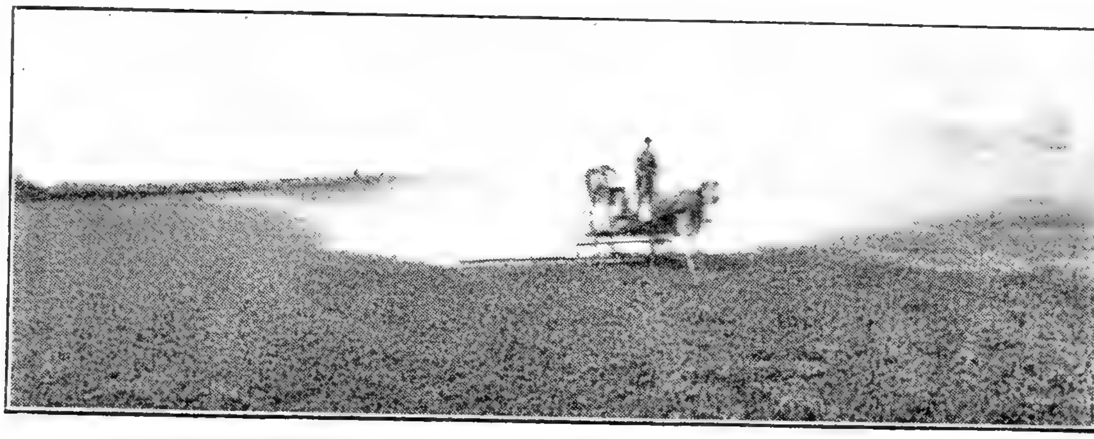


Fig. 2. — The twenty-foot boom covers an acre in fifteen or twenty minutes.

A wide range was covered both in strength of dusts and in amount applied per unit area. The weather conditions and infestations varied greatly during the five-year period.

Wherever possible, the percentage of control as given here is an average based upon the reduction of aphids in all similarly treated plots, which was determined daily for four days after treatment, on treated and check plots alike.

Dusts containing calcium cyanide at different strengths as the active ingredient and carrying talc, hydrated or dolomitic lime were carefully tested in 1923 and 1924. Killing varied from as low as 30% to as high as 88%. The kill could not be correlated with the strength of cyanide nor the amount of material used per acre. Neither was there a consistent correlation with temperature and humidity. We recognized and named this fluctuating percentage of kill "the cyanide complex". Clearly the best results were obtained time after time under conditions often spoken of as heavy, breathless atmosphere — the still, hot days accompanied by high relative humidity. Unfortunately, under these optimum conditions for killing there was an accompanying tendency for foliage injury which appeared in from two days to a week following application.

Numerous dusting combinations, all containing some form of nicotine, have been thoroughly and repeatedly tested in five years. In many tests, the percentages of actual nicotine in the dusts varied from 0.8 to 4.0, and applications of from 25 pounds per acre in the case of the strongest dust up to 93 pounds per acre of the weaker dusts were made. Recorded kills varied from 36% with a 2% dust to 92% with a 2.4% dust. Kills of 70% with an 0.8% dust were recorded under favorable conditions and of only 80% with a 4% dust under unfavorable conditions.

Since 1924 all nicotine dusts have been freshly mixed in the field just before applying, under a supposedly new formula in which monohydrated copper sulfate was used in amounts just double the weight of the nicotine sulfate, the balance being hydrated lime. A common formula used, for instance, was 8 pounds of nicotine sulfate, 16 pounds monohydrated copper

sulfate, 76 pounds hydrated lime. The principal advantages of the monohydrated copper sulfate are: first, an extremely uniform, fine, dry mixture in which the moisture from the nicotine has been taken up by the copper sulfate and lime in the formation of a weak bordeaux mixture, and, second, a prolonged and more even liberation of the nicotine. More uniform and consistent results have been realized from this formula than from nicotine dusts not containing the copper sulfate.

The action of nicotine in dust form is too well understood to make detailed explanation necessary here. Suffice it to say, however, that the effectiveness of nicotine dust as a control for the pea aphid is directly correlated with temperature and wind conditions for several hours subsequent to application. These are the factors of first importance, while strength of nicotine, amount of application, and humidity are modifying but not determining factors. In fact, when considering the expected results of an application of nicotine dust against the pea aphid and certain other insects, we have begun to think in terms of insect activity following treatment rather than the physical and chemical conditions of the treatment.

The sweeping machine, or aphidozer, was originated in 1923 and developed in subsequent years. It is simply a hopper mounted on wheels, above and in front of which a reel carrying six long bristle brushes, revolves by power transmitted through chain gears from one of the wheels. Aphids and other insects are brushed or swept from the foliage into the hopper. The machine takes a seven-foot swath and is drawn by one horse walking in front of one wheel and not in front of the reel. Adjustments enable the hopper to be raised and lowered and the reel to be run at different speeds (text-fig. 3):

Fig. 3. — Sweeping a large field of peas with the aphidozer; note peas on left slightly laid over after machine has passed.

Over forty tests with this machine during a period of five years have resulted in catches, or, as we prefer to express it, reduction of aphid infestation, varying from no reduction to 80% reduction, with an average of 60% reduction for thirty tests, the other tests being concerned principally with mechanical injury and not with aphid reduction.

Many sweepings in heavily infested pea fields have resulted in catches of approximately a bushel of insects alone per acre (text-fig. 4):

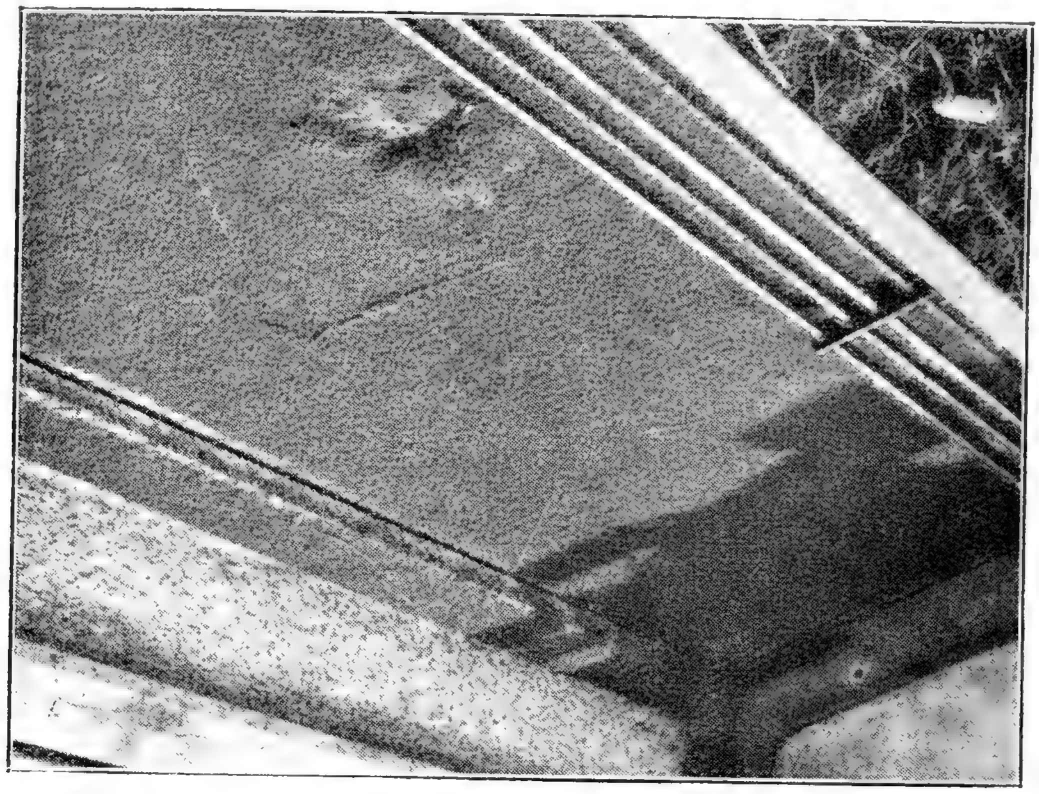


Fig. 4. — Hopper of aphidozer covered with aphids.
They are 1½ inches deep in front. Note the absence of foliage.

The condition of the pea vines under which the largest percentage of reduction of aphids from sweeping may be expected are comparatively short, slender, young vines, standing erect.

The reduction of aphids by sweeping is not half the story of the aphidozer. The all-important factor of mechanical injury will be taken up a little later under the discussion of weather and growth conditions.

Yields. Grade, Rates, Quality. — Yields are expressed in pounds of shelled peas per acre. The grade is based on the percentage of small peas contained in the total yield, the higher this percentage the higher the grade rate. Quality refers to the quality of the canned product.

It must be admitted that too often in the past entomologists have paid principal attention to the percentage of insects killed by different methods, forgetting or not realizing the final effect that their efforts may have upon the ultimate yield and quality of the product under experiment.

To the canner and to the grower, not to mention others directly influenced by agricultural operations, the success of the practice of direct control of any insect pest is judged chiefly if not wholly by its final effect upon the yield and quality of the crop. Might we not profit by using the words control less and yield and quality more?

Data on these vital, final results were not taken until 1924. Again voluminous data must be briefly summarized which, fortunately or unfortunately, is readily accomplished. Although many dusting experiments were already started in 1924, very heavy rains in July made harvesting impossible. Over three inches of rain, falling in less than a week, turned our dusted plots into a temporary pond.

Results from five plots of peas in widely separated fields, each swept once with the aphidozer, were outstanding. Averaging two and one-half acres each, the plots came to harvest offering us the following data:

Reduction of aphids ran from 81 to 91%, averaging 85%. Increase in weight of shelled peas per acre (over appropriate checks) ran from 208 pounds to 1478 pounds, averaging 882 pounds. The increase in yield ran from 20 % to 107 %, averaging 62 %.

Peas were not canned for test as to quality from these swept experimental plots. Cannings made from small garden plots, however, some kept infested and others uninfested, showed generally a superior quality for each size of pea from the uninfested plots.

No dusting experiments were carried on in 1925. Results of aphidozer experiments for this year and both dusting and aphidozer experiments for 1926, 1927 and 1928, totalling 41 complete tests, can be summarized together.

Since 1924, no consistent increase in either total yield or gross income per acre has resulted from dusting and sweeping operations, but the quality of the canned product has often been improved and never lowered.

The gains, losses and averages for each year are given in tabular form to make clear the last statement.

Number of Increases and Decreases with Averages of all Treated Plots compared with their Checks.

Year	Total yields			Grade rates			Gross incomes		
	No. Increases	No. Decreases	Ave. lbs. of shelled peas per acre	No. Increases	No. Decreases	Dollars per 100 lbs. of peas	No. Increases	No. Decreases	Dollars per acre
1925	2	12	— 443	10	3	+ .22	3	10	—11 78
1926	3	8	— 189	6	4	+ .14	5	6	— 5.00
1927	7	8	— 190	8	6	+ .02	5	10	— 7.00
1928	1	1	+ 60	1	1	— .02	1	1	+ 1.00

The results for 1928, showing a slight gain in yield and a very slight one in income, are well within the bounds of experimental error. The point to be made is that no definite, paying increase was realized from two tests, one a dusting and the other a sweeping test.

In 1925 the quality of canned peas from three different fields of two varieties showed a decided improvement in every size of pea from every swept plot. This improvement was due largely to the removal of a heavy concentration of aphids from the small, tender, newly formed pods (text-figs. 5 and 6):

For the three past years the quality of canned peas from dusted and swept plots has not shown regular improvement over peas untreated. It has been appreciably better in some instances and never poorer than the checks. What increase in selling price this slight improvement in quality might have brought to the canning company had their whole acreage been treated was not established and could be arrived at only by opinion, which is not very valuable.

Thus it is evident that the expense and time of practising direct control against the pea aphid in Southern Wisconsin during the four-year period commencing with 1925 would not have been repaid from a commercial standpoint, at least, not as far as the raw product is concerned.

The Growth, Infestation, Injury Complex. — The principal underlying reason for the failure of control measures to increase income (return to the grower) for four out of the past five years, in the presence of a considerable infestation each year, is the interrelation of plant growth, infestation and mechanical injury which is taken up here instead of with the previous data in order to present it as a problem apart, which it is.

There appears to be no yearly correlation between aphid control and income when the factor of plant growth is left out, but there is a most telling one when this factor is included. We speak of income instead of yield, for income is the more final, being yield times grade rate, both of which, as has been shown, are directly affected by control operations.

Fig. 5.

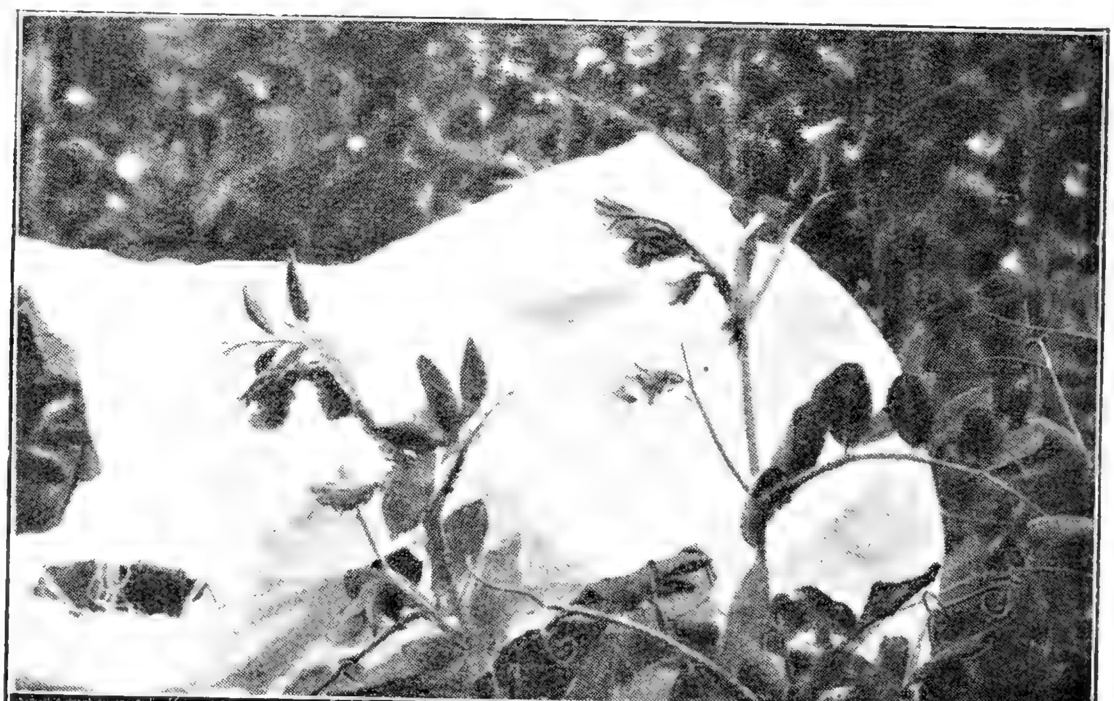


Fig. 6.

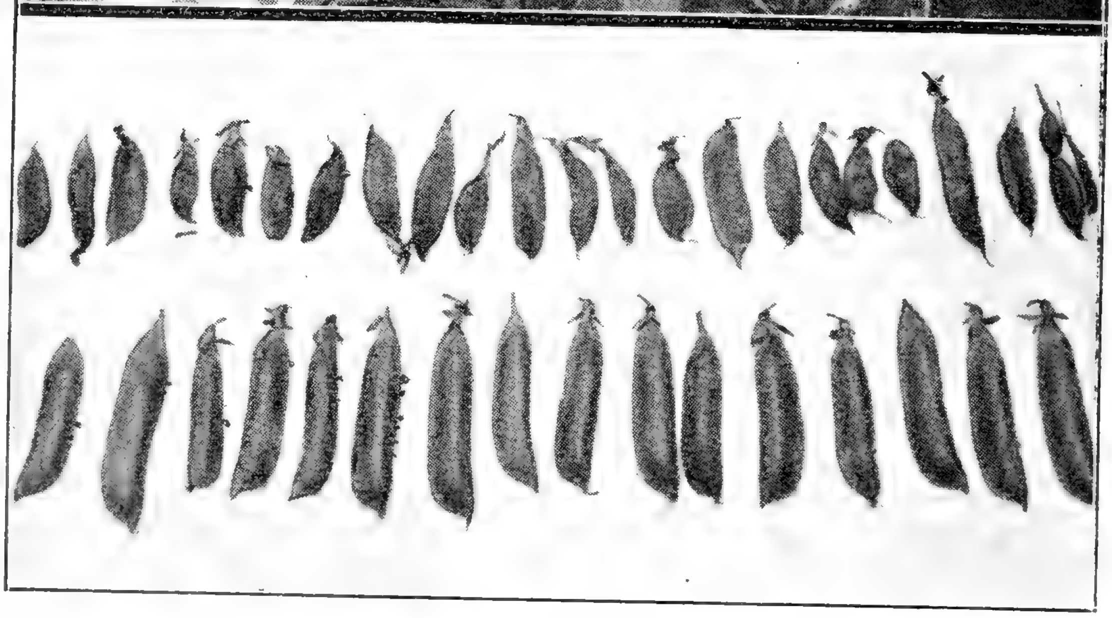


Fig. 5. — An especially heavy infestation of aphids causes the tips of the vines to bend over.

Fig. 6. — Typical pods from heavily infested and uninfested vines. The top row of pods would produce few or no marketable peas.

Observations show that plant growth is the most fundamental factor in income and also very largely modifies the intensity of infestations and effectiveness of measures of control.

Plant growth is, of course, governed by weather conditions, so that these constitute the primary factors in crop production. An analysis of these

conditions and factors for two typical years makes possible an explanation for their respective results.

In the season of 1924 exceptional weather conditions were experienced. The cold, dry weather of spring continued well into July. The mean temperature for May, June and July was well below normal and the rainfall for May and the first half of June was very low. These climatic conditions checked the growth of peas as well as the development of aphids, but checked the vine growth much more. The vines were short, wiry and late in blossoming. Consequently, it was possible to sweep them with little or no mechanical injury and a maximum collection of aphids.

Owing to the growth condition of the vines, then, a somewhat higher percentage of control resulted in 1924 than subsequently, far less mechanical injury was done, and, perhaps most important of all, the vines would not have produced a paying crop under even a moderate infestation. Thus large increases of income resulted from every experiment.

The weather conditions during the growing season of 1925 were nearly the opposite of those of the previous year. The temperature and rainfall were below normal in May and July, but above normal in June. June was one of the wettest months on record. High maximum temperature and abundant precipitation in June following a cool May induced a remarkable and unusual luxuriance of plant growth, heavy, rank, succulent vines which blossomed early and matured early. The aphids, likewise favored by these conditions, increased at an alarming rate, outstripping all their natural enemies.

The peas, however, although very heavily infested, had a surplus of vitality which enabled them to mature more than a normal crop of high quality peas.

On the other hand, the plant growth was of such a nature that any mechanical operation, even walking into the fields, resulted in much more injury to the vines than the aphids did themselves. As mentioned before, the removal of aphids concentrated by the hundreds on newly formed pods slightly increased the grade and quality of canned peas, even though the total yield was decreased.

These two years of 1924 and 1925 in contrast to each other serve to paint the picture of the complexity of the problem. Time does not permit an analysis of 1926, 1927 and 1928. The conditions of plant growth, infestation and mechanical injury for all three years were much more like those of 1925 than those of 1924. Yields and incomes were likewise similar to those of 1925.

Experimental Error. — It will doubtless be of interest to those who carry on large scale field tests to know that we discovered during the progress of our experiments a rather large experimental error. Commencing with 1926, all tests have been conducted on one large tract of highly fertile, fairly uniform land, on the basis of acre or half acre plots, nothing smaller.

Certain discrepancies in results led us to suspect and then to prove by experiment the existence of this large error. Had it not been for general increases in yields in 1924 on the one hand, and for general decreases in 1925, 1926 and 1927 on the other, the experimental error might have made

impossible the conclusions as given. This experimental error is made up of five main and several minor factors. The principal ones are:

(1) Effect of heavy rains in varying the depth of peas after planting, covering some with additional soil, washing the soil from others and washing some peas entirely out of the ground. This results in uneven germination, growth and maturity.

(2) Number of vines per acre.

(3) Accuracy of measurement and judgement of the man charged with this particular work, in deducting from the acreage ditches, weed patches, areas of diseased peas and other abnormalities of stand.

(4) Efficiency of cutting the crop due to driving difficulties, lodged vines, ditches, and obstructions. This results in more pods being left in one plot than in another.

(5) Unevenness of shelling-out peas by different viners.

Some of these factors have been analyzed quantitatively and their value is known. Others challenge the best biomathematical treatment. These factors are so vital, however, that they have necessitated a complete revision of subsequent control experiments from an acre basis to the basis of small, entirely hand-controlled plots.

Natural Enemies.

Through the cooperation of Dr. C. L. Fluke, Jr., of the Wisconsin Experiment Station, who took the leadership in a quantitative study of the pea aphid's natural enemies, it is now possible to know and evaluate the different species concerned, with their individual and total effect in modifying aphid abundance.

Fluke lists seventy-three known predacious and parasitic enemies of the pea aphid in North America *). They belong to the following groups:

Fungi	— 2	species
Arachnida	— 3	species
Orthoptera	— 1	species
Neuroptera	— 4	species
Hemiptera	— 6	species, comprising 4 families
Coleoptera	—22	species, comprising 3 families, of which the *Coccinellidae* alone have 17 species
Diptera	—25	species, all but one included in the family *Syrphidae*
Hymenoptera	—10	species, comprising 3 families, of which the *Ichneumonidae* have 8 species.

The most important groups attacking the pea aphid are *Syrphidae, Coccinellidae,* fungous disease, and Hymenoptera of the genus *Aphidius.* Opinions vary as to the group or groups of first importance. They certainly vary in importance from season to season and in different parts of the United States. One group will greatly predominate one year and the next year be quite scarce.

In 1924 the fungous disease *Entomophthora aphidis* Hoff. clearly held first place among the natural enemies and took very heavy toll of the aphid population, although not before severe crop damage had been sustain-

*) C. L. Fluke, Jr. — Unpublished manuscript.

ed. Since 1924 this disease has not been especially prominent in checking the aphids.

In 1925 and 1926 coccinellids came into first place as natural enemies, with the hymenopterous genus *Aphidius* second. Their combined effect, however, did not constitute control but only a modification of the aphids' abundance.

In 1927 and 1928 a combination of the parasites and predators of four orders was responsible for a certain check in infestation. This natural check did not reach economic proportions, unfortunately, until well along in the season when injury to the crop had already occurred.

Computations show that certain species of insect enemies often number several million per acre and the numeral aggregate of all natural enemies, not counting the fungous disease, must at times run close to the ten million mark per acre. This vast array of natural checks might easily be expected to reduce the infestation almost to the point of extermination, and such an accomplishment has been approached several times towards the fall of the year when the natural reproduction of aphids has greatly slackened. Nevertheless, the acceleration of aphid reproduction has no counterpart among any of its natural enemies, except alone the fungous disease. The aphid is supreme in determining the abundance of its enemies. It furnishes the food supply.

As a matter of record, of the sum total of natural enemies, only the fungous disease mentioned has effected economic control of outbreaks of the pea aphid in Wisconsin during the period of these investigations. It is our opinion, moreover, that unless phenomenal coordination of natural enemy attack should occur, the pea aphid will be often checked, once outbreaks occur, but not profitably controlled by its natural enemies, again the fungous disease excepted.

Seasonal Behavior.

Seasonal Abundance. — A survey of the seasonal abundance of *Illinoia pisi* on alfalfa and peas, the two hosts of major importance in Wisconsin, has been conducted during the period of the investigations relative to control. The seasonal infestation on peas has been studied since 1924, while the populations present upon alfalfa have been studied since 1926. Aphid abundance differs markedly each year, while decided fluctuations are common within each season. The infestation beginning with a small initial population progresses through a series of fluctuations until the maximum population is attained. This peak is then succeeded by a fluctuating decline in the number of aphids.

Stem mothers, in meagre numbers on alfalfa in late April and early May, give rise to a population which induces a general infestation of alfalfa, with the maximum numbers associated with an advanced though succulent growth of the food plant prior to blossoming. The same typical behavior of the species is manifest on peas, where an initial population, consisting of a few migrants, increases to a maximum, the peak of which is always associated with the setting of peas in the pod.

The seasonal and interseasonal fluctuations in total aphid population are governed by many environmental factors, but the peak of abundance attained each season is very closely associated with a specific stage in the

growth of the food plant and for the past five years has always occurred between the 6th and 11th of July. This factor of growth condition of the host is in turn dependent upon climatological factors and soil fertility.

Data collected during the past six years indicate that long periods of cool weather with abundant rainfall constitute seasonal conditions which induce a rank succulent growth of vines, and these conditions have been associated with aphid populations of great magnitude. In contrast to this, hot, dry weather during the growing season constitute conditions which result in short wiry vines and has been accompanied by relatively light infestations.

From the standpoint of the aphid alone, these last two statements constitute a paradox in that hot weather, not too dry, is favorable for its rapid reproduction, whereas periods of cold wet weather are unfavorable. In explanation of this paradox, in the years of heavy vine growth, there have always occurred short periods of weather optimum for aphid reproduction. The combined effect of these short periods of weather and the presence of an unlimited, succulent supply of food has always resulted in very large infestations.

Early in the season of 1924, conditions as previously mentioned were such as to limit vine growth and retard the normal increase of the aphids. With the advent of warm humid weather in the middle of the growing season, an infestation of aphids developed which, considering the sparse growth of vines, threatened to destroy the crop. The appearance of *Entomophthora aphidis* in several sections of the state resulted in a sudden and complete checking of the infestation, which at no time attained the numbers present in 1925.

In contrast to the previous season, the weather conditions in 1925 resulted in a most luxuriant growth of succulent vines, which were capable of supporting a population which at its peak was more than double that of the previous year, and still did no appreciable commercial damage. Moreover, the fungous disease did not constitute a factor of any importance in control this year.

The conditions for the three years past have been much like those of 1925, resulting in an excellent vine growth and associated with aphid infestations of sufficient intensity to be injurious had the growth of vines been at all similar to that of 1924.

Flight. — There occurs but a single annual forced flight movement in the populations of *Illinoia pisi.* This is the movement in July from peas, which both precedes and accompanies the cutting of the crop for canning. In the early part of the season (May and June) winged forms make their appearance upon alfalfa. Some of these individuals serve to distribute the species throughout the alfalfa, while others migrate to peas, where the species remains during the growing season of that crop.

A nominal increase in the number of winged adults caught by tanglefoot screens (text-fig. 7) throughout the months of May and June occurs. The collections up to approximately June 24 represent migrants produced upon the primary host plants alone, as this date marks the initial appearance of winged forms on peas.

The mid-summer flight is pronounced. With the advent of July, the early peas (Alaskas) are harvested, and during the following three to four

weeks the late varieties are cut for canning, although scattered areas are left for seed. A marked increase in the numbers of alate forms is associated with the approach of the harvest of the crop for canning, which precedes plant maturity by approximately two weeks.

During this period of maximum abundance of alate forms on peas, the reverse order of things takes place on the second growth of alfalfa. Here the population is largely apterous until early in August, when winged individuals are again produced on the second stand of alfalfa.

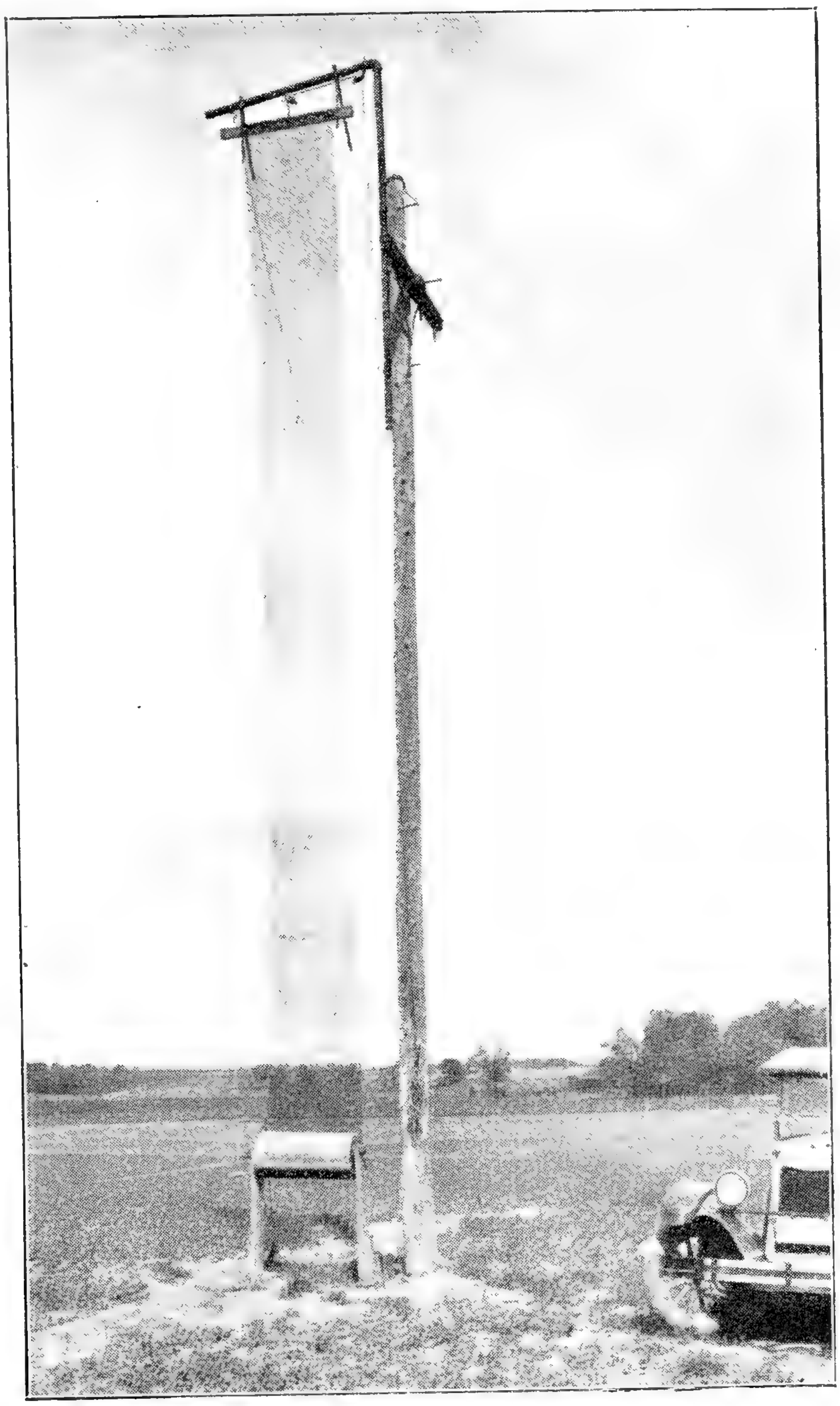


Fig. 7. — Thirty-foot tanglefoot screen for securing a record of the aphids' flight activities.

In a study of the importance of plant composition as a factor influencing wing formation and migration of the species, the matter of plant growth again asserts itself. The maximum number of winged forms are produced on the food plants at approximately the same time the total infestation reaches its seasonal maximum, the latter being closely linked with a specific stage of plant growth.

Quantitative analyses of the food plants at successive dates throughout the season to determine their moisture, nitrogen, sugar and phosphorus contents, indicate that plant composition, especially an abundance of these materials, is associated with wing formation of *Illinoia pisi.* A decrease in the moisture content, which implies a loss of succulence, a decrease in the quantity of total and water insoluble nitrogen and a decrease in the total and inorganic phosphorus in the food plants, are accompanied by an increase in the abundance of alate adults and nymphs. On the other hand, this peak of alate abundance occurs with a gradual increase in the total sugars and reducing sugars and organic phosphorus computed on the wet basis. The quantity of water soluble nitrogen computed on the wet basis increases slowly during the seasonal growth of the food plants and is accompanied by an increase in the abundance of alate aphids.

The relative importance of the constituents studied in influencing wing formation and migration is yet a matter of speculation. The data, however, reveal that there is no appreciable quantitative deficiency in any of the materials studied during the period in which the host is infested. We may find that the availability and utilization of these materials by the aphids is of supreme importance in determining the alate or apterous condition.

Summary.

The great importance of the pea canning industry in the United States and the ravages of the pea aphid over a period of three or four years resulted in the creation of a Federal research project to study control of the insect.

Spraying tests were carried on one year, dusting and sweeping tests for five years. The control of the aphid or reduction in infestation varied from nothing at all to a satisfactory point approaching 90%. The most uniform results were experienced with a nicotine-copper-lime dust.

The effectiveness of dusting was found to be more dependent upon weather conditions at the time of and following treatment than upon the strength of material or amount used per acre.

Results of all kinds of treatments in terms of yield, grade rate, and quality of the canned product could not be correlated with percentage of control if the plant growth factor was ignored.

In 1924 sweeping operations resulted in a decided increase in yield for every field swept.

Since 1924 neither sweeping nor dusting experiments have resulted in any general increase in yield or income, but have shown a loss.

The direct control measures attempted, therefore, have not only been unnecessary during the four past years, but at times actually injurious.

The interrelationship of plant growth, infestation, and mechanical injury constitute an all-important and determining set of factors quite independent of the particular treatment applied. This set of factors in turn is governed by the weather conditions.

Natural enemies, whose species reach nearly four score and whose numbers are legion, effect a constant check upon the pea aphid. This check, although never nil, only approaches effective control, but has never

reached it during the period of these investigations. The fungous disease is the one exception to this statement.

The seasonal abundance of the aphid varies greatly from year to year and has been linked with the growth condition of the vines. The seasonal peak is associated with plant maturity, and during the five past years has occurred between the 6th and 11th of July.

Studies in plant chemistry have shown that there is a close association between wing formation in the aphid and decrease of some and increase of other plant constituents.

The Future of Zoological Nomenclature, with an Appendix: History of Rules *re* Designation of Genotypes.

Ch. Wardell Stiles, Professor of Zoology,
U. S. Public Health Service, and Secretary of the International Commission on Zoological Nomenclature.

The subject assigned to me by your Committee is delightful. It is almost the only proposition in nomenclature I have ever heard in respect to which a speaker can advance views not subject to prompt disproof. If, for instance, I prophesy that 100 years from now, the rules of nomenclature will meet with 100% approval of 100% of the zoologists of the World, no one in this audience can disprove the prophesy, no matter how absurd it appears both to you and to me.

Admitting that the Rules will never meet with 100% approval, it is clear that they must remain what they are today, a compromise based upon mutual, friendly, international concessions. Special national rules (like the A. O. U. Code) are a compromise between different men of one country in a given speciality; general national rules (like the Code of the British Association for the Advancement of Science and that of the German Zoological Society) are a compromise between different men of one country but in different specialities; general international rules are and always must be a compromise between different men, different specialities, and different nations. Argue all one will on the theoretical ideal that science is objective and international, hence that it should not submit to subjective and national views, we face practical as well as idealistic problems, for legislative and administrative ideas and experiences vary in different parts of the world, and international questions must of necessity be considered and determined with this variation in mind. For instance, not long ago a zoologist stated that the Rules of Nomenclature must be "democratic"; I agree with him in this thought, but his ideas of democratic legislation gained in a country which up to about 8 years ago was an empire do not happen to square with my ideas on that subject gained in a country which has been a republic for more that 130 years. Even parliamentary procedure varies in different countries, and this adds to the difficulty of reaching agreements.

With the foregoing basic premise in mind, that the International Rules are and of necessity always must be a compromise, it seems wise not to indulge in "pipe dreams" as to a century from now, but to invite your attention to some of the propositions before the International Commission and also to invite all interested zoologists to communicate to members of the commission their views on these proposals. Whatever

may be my personal views, *pro* or *con*, in respect to these propositions, I will endeavor not to emphasize unduly my own opinions, but to give you the historic background.

Some of the proposals now before the Commission involve restricted portions of the code; three amount almost to a complete rewriting or rearrangement of the rules.

Stability of the International Rules — By all odds, the greatest nomenclatorial question for the future, immediate and remote, is in regard to the stability of the International Rules. Not a few letters are received and not a few propositions are made advising that the International Rules be revised, or, as occasionally expressed, that "they be brought down to date". It is interesting to note, however, that these suggestions are made usually either on purely academic grounds that a given proposal seems reasonable, or because existing rules have caused a change of certain names; and it is exceedingly rare that the proposer of an amendment estimates the extent of the changes which his proposition is likely to entail as compared with the names preserved under the rule he wishes to amend.

The situation today in framing rules is fundamentally different from what it was in 1895 when the International Commission was formed. In 1895 there existed a number of codes, national and international, special and general.

However excellent these various codes were, zoologists did not agree on any one of them. This fact was due largely to two reasons — (1) the special codes were written with prime consideration of the problems of one group, and (2) there was a feeling that in the preliminary studies necessary for the preparation of general codes the membership of the committees was too restricted geographically.

It was Germany that proposed (1895) to form an international commission to codify the existing codes of all specialities and of all countries. The Old World had four representatives, the New World one representative, on this commission. Later (1898) the Commission was increased to 15 members, divided as follows: England 3, France 2, Germany 3, Holland 2, Norway 1, Switzerland 1, Canada 1, United States 2, total Old World 12, New World 3. Africa, Asia, Australia, and Central and South America were not represented.

That there was some criticism in regard to the geographic distribution of the Commissioners is not strange, but in this connection two factors are to be considered, namely: the work required access to large libraries, therefore the distribution of the Commissioners was of necessity restricted, and further, as soon as the Cambridge (1898) and the Berlin (1901) Congresses established the principle that a unanimous vote in Commission was as a *sine qua non,* the argument against a more wide-spread distribution of commissioners weakened from the viewpoint of countries not represented on the Commission.

Not unnaturally different persons will evaluate differently the relative importance of various propositions now under consideration. From an experience of 33 years as a member of the Commission, I am persuaded that the prime, major, question before the

Commission is whether the International Rules shall be stable in principles or subject to reversals.

Amendments may consist of changes in principles, in policies, in wording, in punctuation, and amendments by insertion of new material. It is to changes in principles, namely reversals in Rules, that I refer at present. For instance, should the 12th edition (1766-67) of Linnaeus be adopted in place of the 10th (1758) edition as now provided by the Rules?

The tendency toward stability of the Rules is supported by various factors: — (1) it is unlikely that the Commission would agree unanimously to reverse itself frequently in matters of principles; (2) the Commissioners are elected for a term of 9 years, thus accumulating experience; (3) the term of one third of the Commissioners expires triennially, thus making for slow change in personnel. One factor, however, may easily tend toward reversals of the Rules, namely, when the personnel of the Commission changes new members who were not serving when a given rule was established may wish to reconsider a rule.

There are some members of the zoological profession who do not concur in the present policy of conservatism, but who feel that the rules should be more easily subject to change.

1930 A. — For instance, a proposition (1930 A in the Secretary's records) which the Commission has twice (1913; 1927) declined to accept and which has been resubmitted for reconsideration in 1930, instructs the Commission to report to the Congress all propositions which obtain a majority vote in Commission, and these controversial cases are then to be decided in open meeting by the general session of the triennial Congress. This proposal was presented with a list of about 550 names in 1913 and of about 650 names in 1927 of persons who supported it, but a referendum conducted in the United States showed a vote of 549 against it and only 4 for it.

The chief argument advanced in favor of 1930 A is that it is at present theoretically possible for *one* commissioner to block a change in the rules. One of the arguments advanced against 1930 A is that this theoretical possibility is an important desideratum which makes for conservatism, protects the minority, and protects the rules against unwise change. Another point of view has not been emphasized very much, namely, that the Commission should be free to prescribe its own routine and policies. From still another angle, the practical point has been raised that a general meeting of the Congress is not a favorable place to decide differences of opinion on specialized nomenclatorial questions.

The general feeling in the United States is that concessions have been made and accepted in good faith by the representatives of the different countries; that the rules have been specifically based on unanimous vote in Commission and therefore can be changed only by unanimous vote; further that proposition 1930 A would subject the rules to possible triennial change determined by an accidental and local geographic majority according to the place of meeting; thus if the meeting were held in Austria, the vote would go one way, but if held in the United States, the vote would be in the opposite direction.

1930 B. — As substitute for 1930 A, there is before the Commission a proposition 1930 B reading as follows —

> At least all those proposals for amendments to or addition to the International Rules of Zoological Nomenclature which have obtained —
> *first*, a majority of $^5/_6$ths of the total membership of the Commission of Nomenclature for the time being, and
> *subsequently*, $^5/_6$ths of the votes of those present at the meeting of the Commission,
> shall be the recommendations of the Commission to the Congress.

This is the first public announcement of this proposition. It originated as a compromise between 1930 A and the attitude entertained by many that the entire subject is a *res judicata*.

It requires no great amount of prevision to foretell that many persons will view this substitute as a practical and fair compromise, while others will look upon it as a compromise of a compromise and will therefore view its acceptance not only as calculated to weaken confidence in the rules on the part of countries not represented in the Commission, but also as the beginning of the end of the International Rules. Under these circumstances it is not unnatural that the following proposition is submitted to the Commission —

1930 C. — "The stability of the Rules is a prime and fundamental principle."

Against this proposed principle may be advanced the points that no one generation can bind future generations to any policy, and that each generation must solve its own problems. In favor of the proposed principle may be advanced several thoughts, namely, the exact nature of any given rule is less important than its permanency, for practically any rule if followed long enough will give uniformity; the variation in different codes of rules has been a prolific, in fact a prime cause of confusion in nomenclature, and variation will inevitably result if the International Rules are changed from time to time, for not only must conclusions be reversed, but two authors accidentally but in good faith working with different editions of the code will reach different results.

1930 D. — Another proposition (1930 D) before the Commission is to raise type designation by elimination from the status of a recommendation to the status of a rule. This proposal has three times (1907; 1913; 1927) failed of acceptance in Commission, and it is resubmitted for reconsideration in 1930.

In its support were about 550 signatures in 1913 and about 650 signatures in 1927, chiefly Europeans. The 1927 referendum conducted in the United States resulted in 4 signatures in favor, and 548 signatures against this proposition.

1930 E. — A substitute for 1930 D reads as follows:

> That under Article 30, III of the Rules, the Recommendations *h, i, j,* and *k*, in this order, be raised from the status of recommendations to the status of rules, effective (but not retroactive) after December 31, 1930, or at a date later by not more than 3 years.

Essentially, this compromise is identical in principle with 1930 D except that in addition it (1930 E) raises the provisions of the Linnean Rule, virtual tautonymy, and non-exotic species from recommendations

to rules and gives to them preference over elimination, but is not retroactive; neither 1930 D nor E makes any distinction between species eliminated as types of other genera and species eliminated only as members of new genera or by reclassification in old genera. Fundamentally three preliminary questions of principle arise for consideration, in connection with this subject, namely,

1st) Shall the rules be stable, in accordance with the principle resulting from Cambridge (1898) and Berlin (1901), or subject to reversal on less than a unanimous vote;

2nd) Shall compromises made on unanimous agreement in Commission be subject to recompromise on less than a unanimous vote in commission; and

3rd) Shall a compromise reached at the Boston (1907) meeting between the eliminationists and the 1st species men, and carried out by the 1st species men, be repeatedly subject to reconsideration on representations by an eliminationist?

Let it be assumed, for sake of argument, that the principle of majority vote be adopted as supplanting the principle of unanimity, the situation would then be as follows —

Article 30 involving the various methods of designation of genotypes recognizes various procedures as binding (i. e., as rules) and certain other procedures (on which a wide difference of opinion existed) as optional (i. e., as recommendations), and it applies the law of priority to the action taken. The great principles expressed in Article 30 may be summarized as follows —

1. If an author publishes a generic name, say *X-us* 1800, with type by original designation, namely in words, by monotype, or by absolute tautonymy, his action is not subject to change. But,

2. If neither the original author nor any subsequent author has definitely, unequivocally, validly, designated a type species for *X-us* 1800, any author is at liberty to follow any of several methods according to his views as to what is best in the existing taxonomic situation, and then the Law of Priority is applied to his action.

Thus, Art. 30 *) recognizes practically all divergent views on type-designation, and the adherents of each view give and receive identical concessions, namely, they submit to the law of priority, but type-designation must be definite and unambiguous, namely, "rigidly construed".

The Commission is now asked to reopen and to decide by majority vote certain controversial points (Art. 30 *h, i, j, k,* involving especially the process of elimination) which many persons have accepted in good faith as a *res judicata.* In this reconsideration no provision is made for the other party to that 1907 compromise as represented by Art. 30 *r, s,* and *t,* involving especially the first species rule (preferred by many zoologists) and the French system of chef-de-file.

Here again we may expect pronounced differences of opinion. Some zoologists will view this substitute as a fair compromise; while others

*) An historical summary of the data of which Art. 30 is the final outcome is given as an appendix to this paper.

who consider the subject as a *res judicata* will view it as a proposed compromise of a compromise, which if carried by less than a unanimous vote will shake confidence in the stability of the Rules.

1930 F. — An additional proposition before the Commission is 1930 F, not accepted by the Commission in 1901, 1913, and 1927. This is the more than a century old question of excluding or accepting genera of binary papers (which recognize genera and species), but which are not binominal as to species. It has again been submitted for reconsideration in 1930.

1930 G. — Here again another proposition (1930 G) has been submitted which would dispose of many of the controversial cases against which 1930 F is directed. This partial substitute is —

> To accept the 12th edition (1766-67) of Linnaeus's Systema Naturae as a starting point for the application of the Rules of Nomenclature, thus eliminating many of the papers printed in the transitional stage of 1758 to 1766.

This again reopens an old controversial subject. The 12th edition was accepted by Great Britain, the 10th by continental and by American zoologists. The Commission report of 1901 was unanimous for the 10th edition. Now comes the proposition to reverse the rules and to accept the 12th edition.

Thus you will see that much of the time of the Commission is occupied with reconsideration and rereconsideration of controversies on which unanimous agreement in Commission was reached 21 to 27 years ago, and decisions which have been accepted by numerous zoologists in all parts of the world. The question not unnaturally arises, to whom is the greater consideration now due, to zoologists who have accepted the decisions or to zoologists who have rejected the decisions.

The immediate future of International Rules depends primarily upon coming to a definite international understanding on the generic point as to how much importance is to be attached to the unanimous agreements of the past; and upon this understanding deductions can be based as to how much confidence is justified in majority (namely less than unanimous) agreements in the future. As compared with this fundamental generic point, all specific propositions for amendment to the International Rules are secondary and relatively inconsequential.

I feel certain that you will not confuse the question of *additions to* with the question of *reversals of* the rules. Thus, Art. 25, Law of Priority, has been amended by addition, not by reversal; the addition is not retroactive and it defines more clearly the premise for priority in the future; it accepts the views of both parties to a discussion and asks each party to accept the view of the other; thus each side to the difference of opinion gives and receives equal concessions. Some of the propositions now before the Commission, though not retroactive, call upon one side to a *res judicata* to make practically all the concessions in a recompromise of a compromise.

There is ample room and justification for additions to meet desiderata for some zoological groups, but in considering these desiderata, it is necessary to consider broader questions also. Several zoologists have ex-

pressed the view that while the International Rules should contain only propositions which have been or can be agreed to unanimously by the Commission, separate groups (as entomologists) are justified in adopting special rules for their fields (as for entomology) provided these do not contravene the general International Rules.

There is an undoubted tendency among some zoologists to rewrite, rearrange, reexpress, reedit the rules. This tendency is not new. It was prominent in the 1913 meeting of the Commission, when one of the British representatives (Commissioner Hoyle) made an argument in favor of protecting the Rules against unnecessary and questionable amendments and in favor of building up a series of precedents by the Opinions, then, if necessary, embodying these precedents in additions to the Rules. This plan appealed strongly to the entire Commission.

It is not very difficult for a zoologist to write rules of nomenclature; it is more difficult for him to induce any well-informed specialist in his particular group to agree with him on all paragraphs — for two men to agree usually means concessions by each; as the number of men and of specialities increases, the difficulties increase; protozoologists can agree among themselves more readily than they can agree with entomologists, for each group has special minor premises, special literature, and special problems, despite the fact that the major nomenclatorial purpose is identical in all groups, namely, to seek the utmost stability in names compatible with progressive changes in taxonomy.

1930 H. — Another proposition which probably will be discussed by the Commission at its next meeting is 1930 H, dealing with the definition of "publication". This question has been discussed repeatedly by the Commission, but no unanimously satisfactory conclusion has been reached. Thus this proposition involves not a reversal of former ligislation, but new, constructive, legislation of importance.

As a purely tentative draft, to furnish a summarized basis for study, this proposition at present reads as follows: —

RULE effective January 1, 1931 (and in some parts retroactive). — From the standpoint of the Rules of Nomenclature, Zoological Publication shall consist (or consists) in the *distribution* of zoological documents containing *data intended as record* (i. e., not asking for information). The distribution must be, at least in part, by sale, thus making the documents potentially and reasonably available to the entire zoological profession, and the documents must be manifolded by some method (such as printing) and with materials (permanent ink and fairly stable paper) which promise reasonable permanency.

Preliminary notices are to be considered publication, since it is customary to admit their names to action of the Law of Priority.

The following are not to be considered publication:

a. Anonymous documents of every kind including unsigned reviews and editorials;
b. Deposit of document in public library without simultaneous offering for sale to make it potentially and reasonably available to the entire zoological profession [not retroactive, because of the old university custom of exchange of theses];
c. Documents of any sort not bearing at least the year date;
d. Manuscript (including hard, carbon, and letter press copies);
e. Presentation of paper before meeting of any kind;
f. Printer's proof sheets (galley or page);
g. Separata (including preprints; reprints; etc.), unless these are definitely placed on sale as separate publications;

h. Specimen tags or museum labels, but these take date and published status when quoted in published documents;

i. Reports (no matter how detailed) in the nontechnical press (for instance, political or lay newspapers, lay journals, lay magazines, etc.).

RECOMMENDATIONS. — It is urgently recommended that all zoological documents of record printed in any of the less universally read languages (Chinese, Hungarian, Japanese, Polish, Russian, etc.) be provided with a summary in English, French, German, Italian, Latin, or Spanish.

The date borne by a publication is to be assumed to be correct unless and until proved to be incorrect.

In case of publications bearing more than one year date (example, "Proceedings for the years 1883 to 1885") without a definite year date of issue, the last year (example 1885) may be assumed to be the date of publication for all pages of the volume unless and until an earlier date of issue is proved.

In case of publications bearing only the year date, the actual date of publication for all pages may be assumed to be December 31, unless and until an earlier date of issue is proved.

In case of publications bearing year and month date, the actual date of all pages may be assumed to be the last day of that month, Greenwich time, unless and until an earlier date of issue is proved.

In case of serials, it is recommended that the actual date of publication of each part or number be stated in the next succeeding part or number.

All zoological documents should bear the name and address of the editor or publisher, or publishing organization, and it is well for publishers to report titles promptly to dealers in scientific publications, to zoological bibliographic agencies, and to journals which habitually publish reviews or abstracts.

You will notice that this proposition is an attempt to solve, at least in part, a very complicated question on which there exists a wide difference of opinion. To reach a solution we all must be willing to make concessions to those who differ with us in opinion and we all have a right to expect that they in turn will be willing to make concessions to us. If by mutual and friendly concessions we can reach a unanimous agreement, this will represent a step forward and this assuredly is better than constantly to reconsider and rereconsider a *res judicata.*

How long will it be before the zoological profession reaches the status expressed in the legal maxim: *Interest rei publicae ut sit finis litium* — it concerns the commonwealth [publicus zoologicus — zoological profession] that there be a limit to litigation [controversy].

1930. — Another proposition which is on the program for discussion at the next meeting involves the endings for names of systematic units higher than families. At present, this is in tentative shape, as a Recommendation, as follows: —

It is recommended that superfamily names, based on generic names, be given the ending *oidea.* [As originally proposed by Gill (1872) when he proposed the superfamily as a group. *Four endings are now used for superfamily names: oidea, oidae, oideae,* and *ides.*]

It is recommended that new ordinal names, when based upon generic names, be given the ending *ida* (or *idea?*) and new subordinal names *ina* (or *inea ?).*

As final point in this discussion your attention is most cordially invited to the Official List of Generic Names as a factor in the nomenclature of the future. Zoologists desire permanency of names. Absolute permanency in nomenclature is of course theoretically excluded, because of changes in taxonomic conceptions. But the Official List offers an opportunity for reasonable permanency for the most commonly used generic

names. At present there are 464 names on this list, and about 50 additional names are now under consideration for insertion.

This list has been much misunderstood, but as authors become more familiar with its purpose it grows in favor. If specialists will cooperate to build this list out until it contains about 5000 of the most commonly used generic names with their genotypes, a common ground will have been reached on basis of which the nomina-conservandists and non-conservandists can reasonably unite, and nearly the entire subject of nomenclature will be solved so far as the anatomist, embryologist, pathologist, physiologist, physician, veterinarian, and general zoologist are concerned and it will become, what it should eventually be, a field for opinion and discussion only by the taxonomist. But the taxonomist owes a serious professional duty to these other specialists to give to them a relatively permanent set of unambiguous names and to relieve these other specialists of all unnecessary changes in nomenclature. The systematist who makes himself the slave of rules instead of making the rules his servant and who ignores the far-reaching ramifications of nomenclature does this in good faith, but does he show far-sightedness and judicial temperament?

APPENDIX: History of Rules *re* Designation of Genotypes 1751—1912.

1751: The first principle of type designation ever enunciated appears to be that of Linnaeus 1751a, Philosophia botanica, Paragraph 246, which reads: —

"Si genus receptum, secundum jus naturae & artis, in plura dirimi debet, tum nomen antea commune manebit vulgatissimae & officinali plantae.

1778: This principle was adopted by Fabricius (1778, Philosophia Entomologica) with a slight change in wording, namely, p. 114, § 30.

Si genus receptum secundum leges naturae et artis in plura dirimatur, tum nomen antea commune vulgatissimo insecto manebit.

Scarabaei genus quum dirimerem in *Scarabaeum, Melolontham, Cetoniam, Trichium* et *Lucanum,* necessario *Scarabaeus* hoc nomen commune antea omnibus concedere debui, quum insecta generis frequentissima notissima sint.

From this date down to 1842, many authors designated type species, but they appear not to have formulated any definite series of rules governing their action. The Rudolphi (1801) rules do not mention type species.

1842—65: The British Association (B. A. or Stricklandian) rules were widely published in English, French, and Italian (1844) and represent the second great historical mile-stone in zoological nomenclature. Their influence has been fundamental and world wide. These rules contain the following important provisions regarding type species: —

§ 3. Authors frequently indicate this by selecting some one species as a fixed point of reference, which they term the "type of the genus". When they omit doing so, it may still in many cases be correctly inferred that the *first* species mentioned on their list, if found accurately to agree with their definition, was regarded by them as the type. A specific name, or its synonyms, will also often serve to point out the particular species which by implication must be regarded as the original type of a genus. In such cases we are justified in restoring the name of the old genus to its typical signification, even when later authors have done otherwise.

§ 4. The generic name should always be retained for that portion of the original genus which was considered typical by the author.

§ 5. When the evidence as to the original type of a genus is not perfectly clear and indisputable, then the person who first subdivides the genus may affix the original name to any portion of it at his discretion, and no later author has a right to transfer that name to any other part of the original genus.

§ 6. When two authors define and name the same genus, *both making it exactly of the same extent*, the later name should be canceled *in toto*, and not retained in a modified sense. This rule admits of the following exception: —

§ 7. Provided, however, that if these authors select their respective types from different sections of the genus, and these sections be afterward raised into genera, then both these names may be retained in a restricted sense for the new genera respectively.

[No special rule is required for the cases in which the later of two generic names is so defined as to be *less extensive* in signification than the earlier, for if the later includes the type of the earlier genus [Type by inclusion, see 1905], it would be canceled by the operation of § 4; and if it does not include that type, it is in fact a distinct genus.]

But when the later name is *more extensive* than the earlier, the following rule comes into operation: —

[A later name equivalent to several earlier ones is to be canceled.] (See 1905, § 9.) The same principle which is involved in § 6 will apply to § 8.

§ 8. If a later name be so defined so as to equal in extent two or more previously published genera, it must be canceled *in toto*. [Cf. 1905, § 9.]

Four points of special importance attach to § 5, namely, according to the wording of the rule: —

a. Type designations must be *perfectly clear and indisputable*, cf. "rigidly construed", Art. 30 g.

b. No later author can designate the type species unless he *subdivides* the genus; this provision has been adopted by some authors, but it is not admitted in the International Rules, cf. Art. 30 g.

c. Only the *first* divider of the genus may permanently fix the generic name; this provision is not admitted by authors and surely the committee could hardly have meant it literally.

d. The English word *affix* is a very strong one; it means *to fasten to*, and in view of the first portion of the rule, this *affixing* is obviously by means of "perfetly *clear and indisputable*" designations of a type species. Some authors have extended this point to include elimination, but this is not in harmony with the International Rules.

1842—46. — The Agassiz rules § 4— § 7 are a Latin translation of the B. A. rules.

1844. — The Atti della Quinta Unione degli Scienziati Italiani (1844, of meeting held at Lucca, 1843) contains (pp. 765—766, 819) the following report on those portions of the B. A. rules bearing on type species: —

Rapporto .... Congresso di Lucca sul nuovo piano di nomenclatura, 1843. Adunanze delle Sezioni Riunite di Zoologia e di Botanica per Tenere Ragionamento sulle Leggi di Nomenclatura, pp. 765—766.

V. *Il nome generico sarebbe da ritenersi sempre per quella porzione del genere originale che fu considerata come tipica dall' autore.* Benissimo per i lavori da farsi, ma non cosi per quelli già fatti. Bisognerà tener conto del tempo decorso dopochè un autore ha disviato dalla porzione tipica di un genere la sua primitiva denominazione, dell' autorità di questo autore, e della pratica generalmente osservata dai suoi successori. Per esempio, Latreille ha giustamente suddiviso molti generi del Fabricius, oppure spesse volte egli ha assegnato il nome Fabriciano a una porzione del genere diverso dalla tipica, trasponendo quel nome a un' altra frazione del genere primitivo. I nomi del

Latreille hanno tantosto la vita di due umane generazioni. L' autore è uno dei padri e degli eroi dell' Entomologia. Le sue tracce sono state fedelmente calcate da tutti i suoi connazionali, e da molti fra gli esteri. Arriviamo troppo tardi per andare spigolando le sue minime inavvedutezze, e dobbiamo accettare per forza di legge, i nomi che potremmo desiderarci migliori.

VI. *Quando il tipo originale di un genere non è perfettamente chiaro ed inquestionabile, quegli che primo il suddivide, può apporre a volontà il nome originale a ciascuna porzione di esso, e niuno posteriormente ha diritto di trasferire quel nome ad alcun' altra parte del genere originale.*

Bisognerebbe prevedere il caso in cui lo stesso genere antico fosse passibile di due suddivisioni affatto diverse perchè basate sopra opposti principi, e tali che le specie di ciascun genere della seconda non corrispondessero a quelle dei generi delle altre. In questo caso l' applicazione della legge VI sarebbe arbitraria, a meno che l'autore della prima suddivisione non avesse eletta una data specie per tipo d'ogni genere. La scelta e la chiara indicazione di questo tipo sono pertanto le due condizioni da aggiungersi.

VII. *Quando due autori definiscono e nominano lo stesso genere, dandogli precisamente la medesima estensione, deve essere cancellato totalmente il nome posteriore.*

Mi figuro che col *cancellato totalmente* si voglia dire che il nome posteriore è cansellato dall' anteriore in quel dato luogo, ma non ne segue che queta cancellatura lo sbandisca dalla scienza, anzi mi sembra che rientri nello stuolo dei nomi vaganti e disponibili, e che la libera facoltà restituita a ciascuno di farne un uso più conveniente non sia cosa da tacersi. Ma data pure quella opportuna spiegazione, crederei che questa legge sia troppo generale, che possa soffrire qualche modificazione nella futura pratica, e che sia soggetta a forti eccezioni ne' suoi effetti retroattivi. Queste eccezioni mi sembrano verificarsi. 1.⁰ Se è passato poco tempo fra le due publicazioni. 2.⁰ Se furono fatte a grandi distance di loughi. 3.⁰ Se la prima ebbe una lenta e limitata diffusione. 4.⁰ Se la seconda ha acquistato una quasi irrevocabile autorità in forza degli anni decorsi, della propria importanza, e della fama superiore del suo autore. Una più sminuzzata esposizione di tutte le possibili circostanze, e eccezionabili, mi sembrerebbe inopportuna in giudizio di fatti che non conoscono altre leggi fuorchè quelle della consuetudine e dell' equità.

VIII. *Se il nome posteriore sia così definito da pareggiare la estensione di più generi deve essere cancellato affatto.* Bisognerà ancora eccettuare il caso in cui i più *generi* non meritassero di essere mantenuti, e anzi si dovessero escludere da un sistema naturale. Ne abbiano gli esempi nei primi lavori tentati sopra alcune classi *d' Invertebrati.* Ora dai diversi stati del medesimo animale, ora dai diversi sessi della medesima specie, si sono fatti più specie e più generi, i quali hanno ceduto il posto a un nome unico e posteriore in forza delle scoperte dei più moderni osservatori.

p. 792. Del resto poi, e dai lavori dei deiversi membri della Commissione padovana, e dalle discussioni fatte intorno ai medesimi, tutti gli adunati sentirono il bisogno di rimettere al futuro Congresso di Milano l'esame del progetto inglese; e tutti, trovando giuste le considerazioni fatte dai zoologi milanesi intorno alla non esatta corrispondenza di quello con la versione presentata a Padova, convennero nella necessità di publicarne negli Atti della quinta Unione una versione fedele.

Visto— Il Presidente Principe Carlo Bonaparte e i Segretari della Sezione di Botanica e di Zoologia.

p. 819. Ed io medesimo qui soprascritto, pago di trovarmi quasi in perfetto accordo coi seprasegnati membri della Commissione, dalla quale furono valutate parecchie mie osservazioni ad un primo abbozzo del loro lavoro definitivo, mi restringo a farvi sopra le seguenti riflessioni. E premetto la *FORMAL PROPOSTA,* che sulle basi gettate dagl' Inglesi si redigano più compendiosamente che si possa le *REGOLE DI NOMENCLATURA* sancite dall' autorità dei *CONGRESSI ITALIANI,* valutabilissima tra noi, non leggera presso gli stranieri. Non è ragionevole il supporre che altri si faccia a violarle, e sarebbe irrigionevole che per il solo sospetto di lor violazione si trascurassero; perchè altrimenti non vi sarebbe alcuna norma di scrivere, e neppure di pensare.

1858. — The Protokoll der Entomologen-Versammlung, May 22, at Dresden, as published by the Berliner Entomologische Zeitschrift, contains the following: —

Gesetze der entomologischen Nomenclatur, p. XX.

§ 17. Wird eine Art oder Gattung in mehrere zerlegt, so hat der bis dahin gemeinschaftliche Name dem Bestandtheile der ursprünglichen Art oder Gattung zu bleiben, welcher die typischen Formen enthält.

Vergl. hierzu den sehr beachtungswerthen Aufsatz, Stett. entom. Zeit. 1858, p. 168,9.

§ 18. Als solche typische Formen haben zu gelten:
zunächst die, welche von dem ursprünglichen Begründer als solche bezeichnet worden sind, dann
die, welche die vom Aufsteller angegebenen Charaktere am ausgeprägtesten zeigen, weiter die ansehnlichften, zahlreichsten, häufigsten Formen, und endlich wenn keiner der vorhergehenden Fälle vorhanden ist,
bei Gattungen die zuerst beschriebene Art, bei Gruppen die zuerst beschriebene Gattung.

1867. — De Candolle (1867) treated type designation (Lois de la Nomenclature botanique prepared for the International Botanical Congress, Paris; basis for discussion) as follows: —

Article 54. Lorsqu'un genre est divisé en deux ou plusieurs, le nom doit être conservé et il est donné à l'une des divisions principales. Si le genre contenait une section ou autre division qui, d'après son nom ou ses espèces, était le type ou l'origine du groupe, le nom est réservé pour cette partie. S' il n'existe pas de section ou subdivision pareille, mais qu'une des fractions détachées soit beaucoup plus nombreuse en espèces que les autres, c'est à elle que le nom doit être réservé.

1877. — The Dall (1877) rules definitely introduced the general principle of type by subsequent designation as adopted in Art. 30 g, but in different words as follows: —

LII. When an author has specified no type, it is then necessary, in dividing his genus, to retain his name for the subdivision containing the species which the next subsequent author treating of the genus has specified or regarded as the typical exemplar. B. A. If no subsequent author has selected a type, the first species of the primitive author may frequently be taken as the type, or a species may be selected from among those originally specified as belonging to the genus when it was formed, due regard being paid to the necessity of retaining as many of the original species as possible in the division which is to retain the old name.

According to this wording, the principle of "Type by first species rule" (International Rule Art. 30 recommendation r) was enunciated as a recommendation, as was also the De Candolle rule (International Rules Art. 30 recommendation o.).

1881. — The Chaper rules (1881, De la Nomenclature des êtres organisés, Paris 8°, pp. 1—37, Published by Soc. Zool. France) adopted the principle of "type by elimination" to the exclusion of all other methods except "type by original designation", as follows: —

8° Quand un Genre est subdivisé, le nom ancien doit être maintenu à une des subdivisions, et à celle qui renferme le type originaire du Genre.

Quand le type originaire n'est pas clairement indiqué, l'auteur qui le premier subdivise le Genre, peut appliquer le nom ancien à telle subdivision qu'il juge convenable, et cette attribution ne pourra être modifiée ultérieurement.

1886. — The American Ornithologists' Union, through its Code of Nomenclature and its Check-list, has had an extensive and very salutary influence on nomenclature. The greatest advance, in my opinion, due to the A. O. U. was the formation of its Committee on Nomenclature which administered its Code, as respects North American birds. Rules of Nomenclature, like civil and criminal laws, are good things *per se*, but without machinery for their administration they are likely to be forgotten; further, there are many persons who do not understand the rules and there are many decisions which are made on a very narrow margin and in regard to which there can be a legitimate difference of opinion.

In respect to designation of type species, the A. O. U. Code adopted the following:

Cannon XXI. When no type is clearly indicated, the author who first subdivides a genus may restrict the original name to such part of it as he may judge advisable, and such assignment shall not be subject to subsequent modification.

Cannon XXII. In no case should the name be transferred to a group containing none of the species originally included in the genus.

Cannon XXIII. If, however, the genus contains both exotic and non-exotic species, — from the standpoint of the original author, — and the generic term is one originally applied by the ancient Greeks or Romans, the process of elimination is to be restricted to the non-exotic species.

Cannon XXIV. When no type is specified, the only available method of fixing the original name to some part of the genus to which it was originally applied is by the process of elimination, subject to the single modification provided for by Cannon XXIII.

1889—1891. — The International Rules approved by the first Congress (Paris, 1889) and the second Congress (Moscow, 1892) accepted, as respects type designation, the Chaper (1881) provision verbatim.

Article 35. — Quand le type originaire n'est pas clairement indiqué, l'auteur qui, le premier, subdivise le genre, peut appliquer le nom ancien à telle subdivision qu'il juge convenable, et cette attribution ne pourra être modifiée ultérieurement.

1891. — The Second International Ornithological Congress (Budapest, 1891) treated the subject of type species as follows: —

Hauptbericht, I. Officieller Theil, 1892, pp. 189-190: —

§ 10. Werden Arten, welche früher in einer Gattung vereinigt waren, generisch gesondert, so verbleibt der alte Gattungsname derjenigen Art, welche als Typus angegeben ist, oder welche aus dem Zusammenhange mit *Sicherheit* als solcher gedeutet werden kann. Ist kein Typus angegeben oder zu erkennen, so hat der die Trennung vornehmende Autor die Berechtigung, eine der Arten zum Typus zu bestimmen.

The following quotations are taken from the edition as printed in Ornis, Internationale Zeitschrift für die gesammte Ornithologie v. 7. (4), 1891: —

Erläuterung. Aus vorstehender Bestimmung ergiebt sich notwendig folgendes: Sind die Arten einer älteren Gattung, für welche kein Typus angegeben oder erkennbar ist, nach und nach von späteren Autoren zu Vertretern neuer Gattungen erhoben worden, ohne daß auch von diesen Autoren für die älteste Gattung ein Typus bestimmt worden ist, so bildet die zuletzt übrig bleibende Art den Typus der ältesten Gattung. [Compare elimination. — C. W. S.]

p. 300. Dr. Reichenow aus Berlin referierte über einen von H. v. Berlepsch (Münden), W. Blasius (Braunschweig), A. G. Meyer (Dresden), K. Möbius (Berlin) und Anton Reichenow (Berlin) aufgestellten und von der „Deutschen Ornithologischen Gesellschaft" angenommenen „Entwurf von Regeln für die zoologische Nomenclatur".

p. 308. Nach eingehenden Debatten wurde der Entwurf mit geringen Abänderungen, die oben im Texte bereits eingefügt wurden, angenommen, und der Vorsitzende ersucht, sich bezüglich dieses Entwurfes einer Nomenclatur mit der Deutschen Zoologischen Gesellschaft, sowie mit der Commission des im Jahre 1892 in Moskau stattfindenden internationalen zoologischen Congresses in Verbindung zu setzen.

1894. — The Rules adopted by the Deutschen Zoologischen Gesellschaft apparently made it mandatory ("hat") that the person who divides a genus should designate its type in case this has not already been done.

§ 26. Wird eine Gattung in mehrere neue Gattungen aufgelöst, so verbleibt der alte Gattungsname der als Typus anzusehenden Art. Ist eine solche nicht mit Sicherheit festzustellen, so hat der die Auflösung vornehmende Autor eine der ursprünglich in dieser Gattung enthalten gewesenen Arten als Typus zu bestimmen. Werden Untergattungen zu Gattungen erhoben, so wird der Untergattungsname zum Gattungsnamen.

The foregoing historical review, from 1751 to 1894, shows the pronounced differences of opinion on type determination, which obtained in

different countries and in different specialities. Not only in respect to this phase of nomenclature, but also in regard to many other points, opinions varied in different parts of the world, and the situation as represented by the four nations which had recently paid special attention to the subject was essentially as follows: —

French influence had predominated in the formulation of the Rules of the International Zoological Congress.

German influence had predominated in the formulation of the Rules of the International Ornithological Congress.

The Stricklandian (B. A.) Code still remained the outstanding British influence.

North American Zoologists were divided between the rules of the American Ornithologists' Union, the Dall Code, the International Zoological Rules and the Stricklandian Rules.

The foregoing situation induced Prof. Franz Eilhard Schulze (Berlin, Germany) to propose to the Leyden (1895) International Zoological Congress the appointment of an International Commission to study these various codes in the hope of presenting one which would be really accepted internationally.

The task before the Commission was not an easy one and naturally final results were not immediately forthcoming. The year following the appointment of this Commission and before its report was formulated still another set of rules appeared, namely: —

1896. — The Walsingham and Durrant Rules of Nomenclature limited the type species (§ 40) to specimens seen by the original author (a plan which would deprive a considerable number of genera of type species) and adopted unrestricted elimination as applied both to the original author (§ 42) and to other authors (§ 44) as follows: —

40. The type of a genus must be one of the species originally placed in the genus by its founder, but no species can be regarded as a possible type if it can be shown that the founder of the genus had not seen it.

[N. B. — This and the following rules (40—47) apply with equal force to the sections of any grade.]

41. A genus from its foundation belongs to one of three classes: —

(1) MONOTYPICAL (i. e. described from a single species, no other being known; or described from a single specified species with which are associated other species considered to be identical in structure)."

(2) ISOTYPICAL (i. e. described from more than one species, all of which are congeneric).

(3) HETEROTYPICAL (i. e. described from more than one species, these differing in structure).

[In class *one*, the single species described, or the single species cited, is the type. In classes *two* and *three*, the sum of the species therein contained constitutes the „type" of the *original* author, unless it was indicated that one or more of these species were not considered to be typical.]

42. If the author of an isotypical or heterotypical genus subsequently removes one of his original types to another genus, this species ceases to be a possible type for the genus in which it was first placed.

43. In ascertaining the type of a genus not monotypical, absolute adherence must be given to the Law of Priority.

44. He who first restricts a genus under its own name limits the possible type to one of the species included in his restriction: but, if possibly avoidable, a heterotypical genus must not be restricted to the detriment of an existing monotypical or isotypical genus.

45. When a heterotypical genus by restriction or specification of type becomes monotypical, the single species to which it is limited must thenceforth be accepted as the type of the genus, provided that this species had not previously been constituted the type of another genus.

46. Restriction is effected by omission, by elimination, or by specification.

47. The name of a heterotypical genus dates from its publication, but it dates as a genus from the time that it became isotypical or monotypical.

48. If a subsequent author subdivide a heterotypical genus, distributing its types among differently named genera but retaining the original name as a subgeneric heading in more than one genus to which he refers a type, the Law of Priority shall be rigidly enforced, and his first limitation shall be taken as restricting the type; BUT should he in addition make use of the heterotypical generic name in a generic sense, it shall be held that it was his intention to limit the type to the species referred to in this sense, and his previous subgeneric limitation shall be ignored.

1898. — An exceedingly interesting and important correspondence on the subject of "Nomenclature of Lepidoptera: Correspondence relating to questions circulated by Sir George F. Hampson, Bart.", was published by Durrant in 1898. Opinions are cited from Prof. Scudder, Prof. Fernald, Prof. J. B. Smith, Dr. Staudinger, Heer P. C. T. Snellen, Prof. Aurivillius, Prof. A. R. Grote, Lord Walsingham, E. Meyrick, Esq., W. E. Kirby, Esq., and Sir G. F. Hampson.

Of these, Snellen stood alone in totally rejecting the system of generic types. The following is an analysis of the replies of the other ten men: —

1. The type of a genus must be a species originally included in it by its founder. (Adopted by all ten men.)

2. The type must conform to the original description of the genus (a species excluded by the description cannot be the type). (Adopted by all ten men.)

2 A. Unless direct error of observation can be inferred. (Meyrick and Kirby).

2 B. And to the meaning (if any) of the generic name. (Meyrick, Kirby, Hampson, Walsingham).

3. That a species included with doubt can not be type. (Walsingham, Grote, Kirby).

4. That a *name* included (without the species being known to the founder) can not establish any claim to the recognition of the *species* as a possible type. (Adopted by Hampson, Walsingham, and Smith; apparently opposed by Kirby.)

5. The first species, or the first species agreeing with the description to be considered the type. (Adopted by Hampson and Staudinger; opposed by other eight.)

6. Subsequent citation or restrictions must be accepted in chronological sequence:

6 A. If they are not at variance with the original intention of the author (Walsingham, Meyrick, Kirby, Fernald, Smith, Scudder, Grote, apparently Staudinger).

6 B. Disregarding the *supposed* intentions of the author, but not any clear or evident intention (Grote).

6 C. Providing that the subsequent author expressly fixed the type or *intentionally* divided the genus and that he retained the old name for one part; the effect of omission of species from merely faunitic works to be ignored (Aurivillius).

6 D. A species subsequently removed by the founder to another genus ceases to be a type of the original genus (Walsingham).

7. When the historical method has been exhausted the species (or group of species) which agrees best with the description should be regarded typical (Walsingham, Meyrick, Fernald, Smith, Aurivillius).

7 A. But if all equally agree the type may be fixed at discretion (Meyrick, Walsingham, Smith).

7 Aa. But would assume the type to be a species from the author's own country, the one with which he seems to be most familiar, and if the preparatory stages are mentioned should assume the commonest species (as the one with which he was likely to have the greatest acquaintance) to be the type (Smith).

7 B. If all agree equally well the first species is the type (Fernald, Kirby).

7 C. If two or more agree better than the remainder, the first of those that do agree is the type (Fernald, Kirby).

7 D. If one species is more fully described than the others, or if it is figured, it should be regarded as the type (K i r b y).

7 E. The majority of homogeneous species should be taken as representing a restricted genus (K i r b y).

8. If the generic characters are *better developed* in one species (or group of species) this species (or group) must be held typical. (Apparently ignoring previous action.) (A u r i v i l l i u s).

9. If the description and included species prove that two or more genera were intended to include the same animals, they must be regarded as synonyms. (See B. A. Code, § 6.) (A u r i v i l l i u s.)

[9 A. If, however, the *original types* of these genera were heterotypical, each of the genera is valid for its own type. (B. A. Code, § 7.) (D u r r a n t.)]

9 B. If types heterotypical in structure have been assigned to each genus (there being no evidence to disprove the possibility of their having been the *original types*), the genera should be accepted in their restricted sense (D u r r a n t).

Several tentative arrangements of the work of the International Commission were printed pending the preparation of the joint official version.

1920. — For instance, the (1902) Verhandlungen of the Berlin (1901) Congress contained an arrangement of the Rules with the following introduction by Prof. M a t s c h i e: —

Die hier veröffentlichten Regeln der Zoologischen Nomenklatur sind auf Grundlage der Beschlüsse des V. Internationalen Zoologen-Kongresses in Berlin (vergl. Verhandlungen, p. 886 ff.) nach dem Wortlaut der Berichte der in Leiden gewählten Internationalen Nomenklatur-Kommission (Paris 1897, Leipzig 1898) zusammengestellt. Sie können also als Meinungsausdruck des V. Internationalen Zoologen-Kongresses so lange gelten, bis die von den Herren R. B l a n c h a r d, F r. v o n M a e h r e n t h a l und C h. W. S t i l e s zu bearbeitende und redigierende Neuauflage der Regeln erschienen ist.

In this edition, which was not edited by the subcommittee, the following passages occur in regard to designation of type species: —

p. 966. § 1. When a genus is divided into two or more restricted genera, the original name (if otherwise valid) must be retained for one of the restricted genera; if a type species has been proposed, the division containing that species must retain the (otherwise valid) generic name.

The name of the typical subgenus must be the same as the name of the genus.

§ 2. If the original type of the genus is not clearly indicated, the author who first subdivides the genus may apply the original generic name to such restricted genus as he may judge advisable, and such assignment is not subject to subsequent modification.

In no case, however, can the original name be transferred to a group containing none of the species originally included in the genus; nor can a species be selected as type which was not originally included in the genus, or which the author of the original genus doubtfully referred to it.

Recommendation, p. 971, § 7. In selecting a type authors should govern themselves by the following:

1. A genus which contains a species bearing the same name, either as a valid name or synonym, takes that species as type.
2. Select as type some species which the original author studied, unless it can be definitely shown that he had some other species more particularly in mind.
3. [If the genus has already been divided by former authors, without the specification of types, the only available method of fixing the original name to some part of the genus to which it was originally applied is, of course, by the process of elimination, but:]

   If the genus contains both exotic and non-exotic species, from the standpoint of the original author, the process of elimination is to be restricted to the non-exotic species.
4. Select as type the species which is best described, or best figured, or best known.

There were some differences between the English, French, and German editions and these were not straightened out until 1904—1905.

1904—5. — The special subcommittee edited and rearranged the International Rules at the Berne (1904) Congress and they were published (1905) in English, French, and German. This joint edition contained the following provisions regarding type species: —

Art. 29. — If a genus is divided into two or more restricted genera, its valid name must be retained for one of the restricted genera. If a type was originally established for said genus, the generic name is retained for the restricted genus containing said type.

Art. 30. — If the original type of a genus was not indicated, the author who first subdivides the genus may apply the name of the original genus to such restricted genus or subgenus as may be judged advisable, and such assignment is not subject to subsequent change.

In no case, however, can the name of the original genus be transferred to a group containing none of the species originally included in the genus; nor can a species be selected as type which was not originally included in the genus, or which the author of the generic name doubtfully referred to it.

Recommendation. — In selecting a type, authors should govern themselves by the following:

a. A genus which contains a species bearing the same name, either as a valid name or as a synonym, takes that species as type.

b. Select as type some species which the original author studied personally, unless it can be definitely shown that he had some other species more particularly in mind.

c. If the original genus has already been divided without designation of type, the type should be restricted by elimination, namely, by successively rejecting all the species which have already been transferred to other genera; the type is then selected from the species which remain.

If the genus contains both exotic and non-exotic species, from the standpoint of the original author, the type is to be selected from the non-exotic species.

d. Select as type the species which is best described, or best figured, or best known.

1904. — The Nomenclature Commission of the Botanical Club of the American Association for the Advancement of Science proposed the following rules for type-fixations.

Cannon 15. — The nomenclatorial type of a genus or subgenus is the species originally named or designated by the author of the name. If no species was designated, the type is the first binomial species in order eligible under the following provisions:

(a) The type is to be selected from a subgenus, section or other list of species originally designated as typical.

(b) A figured species is to be selected rather than an unfigured species in the same work; or, in the absence of a figure, preference is to be given to a species accompanied by the citation of a figure.

(c) The types of genera adopted through citations of nonbinomial literature (with or without change of name), are to be selected from those of the original species which receive names in the first binomial publication. The genera of Linaeus's Species Plantarum (1753) are to be typified through the citations given in his Genera Plantarum (1754).

(d) When a prebinomial generic name is displaced by the publication of a generic name within binomial usage, the application of the displaced name to a species under the new generic name designates the type.

(e) The application to a genus of a former specifie name of one of the included species, designates the type.

(f) To avoid change in the current application of a Linnaean generic name, a well-known economic species may be selected as the type, in accordance with the principles stated by Linnaeus (Phil. Bot. 197, 1751): 'Si genus receptum, secundum jus naturae et artis, in plura dirimi debet, tum nomen antea commune manebit vulgatissimae et officinali plantae.'

1904. — Closely following the work of the subcommittee in Berne, Professor von Maehrenthal, the German representative, published (1904) a draft which he proposed as basis for a new study of the International Rules. This draft contained the following features bearing on type designations and emphasizing the process of elimination: —

Art. 13. Erklärungen.

h) γ) Ein Teil einer Einheit wird vor einem anderen Teil derselben Einheit bevorzugt: 1) wenn er urprünglich (d. h. bei der Begründung der Einheit, also von dem Autor bei der Einführung der ursprünglichen Namen der Einheit) oder in einer Veröffentlichung, in der eine Teilung der Einheit vorgenommen wird, als Typus oder als typisch bezeichnet, oder mit dem Art- oder Unterartnamen *typus* oder *typicus* (*-a, -um*) benannt wird (Typus-Bestimmung), oder 2) wenn ihm bei der Teilung der Einheit durch Begründung neuer Einheiten der Name der ursprünglichen Einheit als gültige Benennung belassen wird (Elimination). — Werden von demselben Schriftsteller in derselben Veröffentlichung durch Bezeichnung und durch Benennung verschiedene Teile der Einheit als Typus bestimmt, so ist nicht die Benennung, sondern die Bezeichnung als maßgebende Bevorzugung anzuerkennen. Werden Körper, deren Zugehörigkeit zur Einheit ursprünglich als mehr oder minder unsicher bezeichnet wurde, durch Typus-Bestimmung oder Elimination bevorzugt, so ist diese Bevorzugung nicht als maßgebend anzuerkennen.

i) Der Typus einer Einheit wird durch Anwendung des Prioritäts- und Autoritätsgesetzes ermittelt und ist entweder ihr ganzer ursprünglicher Inhalt (die ursprüngliche Einheit, vergl. Art. 5, Erbl. a) oder derjenige Teil desselben, der auf Grund erfolgter Typus-Bestimmung oder Elimination bei der Anwendung des für die Einheit eingeführten Namens zu bevorzugen ist. Typus einer Einheit kann nur ein solcher Teil derselben sein, der bei der Begründung der Einheit ihr zugerechnet und nicht als ihr nur zweifelhaft zugehörig bezeichnet wurde. Durch genauere Ermittelung des ursprünglichen Inhaltes einer Einheit kann eine weitere Begrenzung ihres Typus zu einer engeren werden; fortschreitende Teilung des ursprünglichen Inhaltes einer Einheit führt durch Typus-Bestimmung oder Elimination zu engeren Begrenzungen ihres Typus. — Typisch für eine übergeordnete Einheit ist diejenige untergeordnete Einheit, welche den Typus der übergeordneten Einheit enthält.

j) Ist eine ursprüngliche Einheit, für welche ursprünglich der Typus nicht bestimmt worden ist, zu teilen, so ist für die gültige Anwendung ihres Namens das Verfahren derjenigen Veröffentlichung maßgebend, in welcher eine Teilung der ursprünglichen Einheit vorgenommen und entweder 1) ein Teil derselben als Typus bestimmt, oder 2) durch Begründung neuer Einheiten für einen Teil der ursprünglichen Einheit, also durch Elimination, die Anwendung ihres Namens für den übrigbleibenden Teil eingeschränkt wird. — Werden durch zwei Teilungen der bezeichneten Art verschiedene Teile, von denen jedoch einer den anderen einschließt, zum Typus, so ist die engere Begrenzung desselben als maßgebend anzuerkennen. Werden durch zwei Teilungen verschiedene Teile, von denen jedoch jeder einen Teil des anderen einschließt, zum Typus, so gilt der beiden gemeinsame Teil als enger begrenzter Typus. Werden durch zwei Teilungen in nicht-gleichzeitigen Veröffentlichungen verschiedene, einander ausschließende Teile zum Typus, so ist das Verfahren der früheren Veröffentlichung als maßgebend anzuerkennen. Werden durch zwei Teilungen in derselben oder in gleichzeitigen Veröffentlichungen verschiedene, einander ausschließende Teile zum Typus, so ist die autoritative Bestimmung des ersten Schriftstellers als maßgebend anzuerkennen, der einen der Teile vor dem anderen bei der Anwendung des Namens der geteilten Einheit bevorzugt. — Wird von einem Schriftsteller in einer Veröffentlichung bei der Teilung der ursprünglichen Einheit infolge Begründung neuer Einheiten für alle Teile der ursprünglichen Einheit die Anwendung ihres Namens nicht eingeschränkt, so ist die autoritative Bestimmung des ersten Schriftstellers als maßgebend anzuerkennen, der für eine der neu begründeten Einheiten den neu eingeführten Namen als Synonym zu Gunsten des Namens der geteilten Einheit verwirft.

The question of type designation was so complicated that the Secretary made a special study of this phase of nomenclature in preparation for the work of the Boston (1907) meeting.

1905. — In preparation for the Boston (1907) meeting the Secretary tabulated the various methods of type designation, tested them out on the

entire group of Nematoda, published his studies as Bull. 19, U. S. Bureau of Animal Industry, and submitted the following recommendations to the Commission: —

1. Rule. — A genus proposed with a single original species takes that species as type. (Monotypical genera.) [Adopted as Rule, Art. 30 c.]

2. Rule. — The type of a genus (containing, from the standpoint of the original author, both valid and doubtful species) must never be selected from the species which the original author of the genus clearly designated as species inquirendae at the time of the publication of the generic name. [Adopted as Rule, Art. 30 e β].

3. Rule. — When in the original publication of a genus one of the species is definitely designated as type, this species should be accepted as type, regardless of any other considerations. (Type by original designation.) [Adopted as Rule, Art. 30 a.]

4a. Rule. — If, in the original publication of a genus, *typicus* or *typus* is used as a *new* specific name for one of the species, such use shall be construed as "type by original designation." [Adopted as Rule, Art. 30b.]

4b. Recommendation. — It is well to avoid the introduction of the names *typicus* or *typus* as new names for species or subspecies, since such names are always liable to result in confusion later. [Adopted as Rec. sub Art. 14.]

5. Rule. — If a genus, without designated type, contains among its original species one possessing the generic name as its specific or subspecific name, either as valid name or synonym, that species or subspecies becomes ipso facto type of the genus. (Type by absolute tautonymy.) [Adopted as Rule, Art. 30d.]

6. Recommendation. — If a genus, without designated type, contains among its original species one possessing as specific or subspecific name, either as valid name or as synonym, a name which is virtually the same as the generic name, or of the same origin or same meaning, preference should be shown to that species in designating the type, unless such preference is strongly contraindicated by other factors. (Type by virtual tautonymy.) [Adopted as Rec., Art. 30i.]

7. Rule. — In case a generic name without designated type is proposed as a substitute for another generic name, with or without type, the type of either when established becomes ipso facto type of the other. [Adopted as Rule, Art. 30f.]

8. Rule. — If an author proposes a genus, without designating a type, and includes among the original species [i. e., the valid species from his standpoint] the determined type of an earlier genus, such type becomes ipso facto the type of the new genus. (Type by inclusion.) [Not adopted.]

9. Rule. — If a genus without a designated type contains types of two or more earlier genera, the type of the new genus is to be selected from the contained types (the case being the same as a genus with two or more species, according to the number of types in question), unless it can be shown that such procedure is directly contraindicated by the original author's intentions. [Not Adopted.]

10. Rule. If an author, in publishing a genus with more than one valid species, fails to designate or to indicate its type, any subsequent author may select the type, and such designation is not subject to change. (Type by subsequent designation.) [Adopted as Rule, Art. 30g.]

11. Rule. Certain biological groups which have been distinctly proposed as collective groups, but not as systematic units of generic rank, may be treated for convenience as if they were genera, but they require no type species. Example: *Agamodistomum.* [Adopted as Rec. sub Art. 8.]

12a. Rule. — The following species are excluded from consideration in selecting types of genera:

(a) Species which were not included under the generic name at the time of its original publication. [Adopted as Rule, Art. 30 e α].

(b) Species which were *species inquirendae* from the standpoint of the author of the generic name at the time of its publication. [Adopted as Rule, Art. 30e β.]

(c) Species which the author of the genus doubtfully referred to it. [Adopted as Rule, Art. 30e γ.]

(d) Species which have subsequently been selected to serve as types for other genera, unless this applies to all of the available species, in which case the last species so selected becomes the type of the original genus; or unless the species which the original author took as his type has been transferred, in which case the original

author's intentions should be carried out. (Type by elimination.) [United with 12c(b) as Rec. Art. 30k.]

12b. Rule. — In case of Linnaean genera select as type the most common or the medicinal species. (Linnaean rule.) [Adopted as Rec. Art. 30h.]

12c. Recommendation. — The following species should be shown preference in selecting the type, unless such procedure is contraindicated by the original author's intentions or by practical considerations:

(a) If the genus contains both exotic and nonexotic species from the standpoint of the original author, the type should be selected from the nonexotic species. [Adopted as Rec. Art. 30j.]

(b) If some of the original species have later been classified in other genera, but not designated as their types, preference should be shown to the species still remaining in the original genus. [United with 12a (d) as Rec. Art. 30k.]

(c) All other things being equal, page precedence should obtain in selecting a type. [Adopted as Rec. Art. 30t.]

(d) Species based upon sexually mature specimens should take precedence over species based upon larval or immature forms. [Adopted as Rec. Art. 30l.]

(e) All other things being equal, show preference to a species which the author of a genus actually studied at or before the time he proposed the genus. [Adopted as Rec. Art. 30q.]

(f) Show preference to a species bearing the name *communis, vulgaris, medicinalis,* or *officinalis.* [Adopted as Rec. Art. 30m.]

(g) Show preference to the best described, best figured, best known, most easily obtainable species, or of which a type specimen can be obtained. [Adopted as Rec Art. 30n.]

(h) Show preference to a species which belongs to a group containing as large a number of the species as possible. [Adopted as Rec. Art. 30 o.]

(i) In parasitic genera, select if possible a species which occurs in man or in some food animal, or in some very common and widespread host. [Adopted as Rec. Art. 30p.]

1905. — Briquet's Report to the International Botanical Congress 1905. (Texte synoptique des Documents destinés à Servir de Base aux Débats du Congrès international de Nomenclature botanique) held at Vienna, contains the following proposition: —

Article 54. Lorsqu'un genre est divisé en deux ou plusieurs, le nom doit être conservé et il est donné à l'une des divisions principales.

Si le genre contenait une section ou autre division qui, d'après son nom ou ses espèces, était le type ou l'origine du groupe, le nom est réservé pour cette partie.

S'il n'existe pas de section ou subdivision pareille. mais qu'une des fractions détachées soit beaucoup plus nombreuse en espèces que les autres, c'est à elle que le nom doit être réservé.

1907. — As finally adopted after unanimous vote in Commission at Boston, Article 30 stands as follow:

Article 30. — The designation of type species of genera shall be governed by the following rules (a-g), applied in the following order of precedence:

I. Cases in which the generic type is accepted *solely* upon the basis of the original publication:

a) When in the original publication of a genus, one of the species is definitely designated as type, this species shall be accepted as type, regardless of any other considerations. (Type by original designation.)

b) If in the original publication of a genus, *typicus* or *typus* is used as a *new* specific name for one of the species, such use shall be construed as "type by original designation".

c) A genus proposed with a single original species takes that species as its type. (Monotypical genera.)

d) If a genus, without originally designa ed (see *a*) or indicated (see *b*) type, contains among its original species one possessing the generic name as its specific or subspecific name, either as valid name or synonym, that species or subspecies becomes *ipso facto* type of the genus. (Type by absolute tautonymy.)

II. Cases in which the generic type is accepted not solely upon basis of the original publication:

e) The following species are excluded from consideration in determining the types of genera:

α. Species which were not included under the generic name at the time of its original publication.

β. Species which were *species inquirendae* from the standpoint of the author of the generic name at the time of its publication.

γ. Species which the author of the genus doubtfully referred to it.

f) In case a generic name without originally disignated type is proposed as a substitute for another generic name, with or without type, the type of either, when established, becomes *ipso facto* type of the other.

g) If an author, in publishing a genus with more than one valid species, fails to designate (see a) or to indicate (see b, d) its type, any subsequent author may select the type, and such designation is not subject to change. (Type by subsequent designation.)

The meaning of the expression "select the type" is to be rigidly construed. Mention of a species as an illustration or example of a genus does not constitute a selection of a type.

III. Recommendations. — In selecting types by subsequent designation, authors will do well to govern themselves by the following recommendations:

h) In case of Linnaean genera, select as type the most common or the medicinal species. (Linnaean rule, 1751.)

i) If a genus, without designated type, contains among its original species one possessing as a specific or subspecific name, either as valid name or synonym, a name which is virtually the same as the generic name, or of the same origin or same meaning, preference should be shown to that species in designating the type, unless such preference is strongly contraindicated by other factors. (Type by virtual tautonymy.) Examples: *Bos taurus, Equus caballus, Ovis aries, Scomber scombrus, Sphaerostoma globiporum;* contra-indicated in *Dipetalonema* (compare species *Filaria dipetala,* of which only one sex was described, based upon one specimen and not studied in detail).

j) If the genus contains both exotic and nonexotic species from the standpoint of the original author, the type should be selected from the nonexotic species.

k) If some of the original species have later been classified in other genera, preference should be shown to the species still remaining in the original genus. (Type by elimination.)

l) Species based upon sexually mature specimens should take precedence over species base upon larval or immature forms.

m) Show preference to species bearing the name *communis, vulgaris, medicinalis* or *officinalis.*

n) Show preference to the best described, best figured, best known, or most easily obtainable species, or to one of which a type specimen can be obtained.

o) Show preference to a species which belongs to a group containing as large a number of the species as possible. (De Candolle's rule.)

p) In parasitic genera, select, if possible, a species which occurs in man or some food animal or in some very common and widespread host species.

q) All other things being equal, show preference to a species which the author of the genus actually studied at or before the time he proposed the genus.

r) In case of writers who habitually placed a certain leading or typical species first as "chef de file", the others being described by comparative reference to this, this fact should be considered in the choice of the type species.

s) In case of those authors who have adopted the "first species rule" in fixing generic types, the first species named by them should be raken as types of their genera.

t) All other things being equal, page precedence should obtain in selecting a type.

Self-understood, with different specialities, different nationalities, and different views involved, the final form of Article 30 was a compromise and the various Commissioners each made concessions in order to reach a unanimous and harmonious report. But after making concessions, I stand by them without complaint, however much I may or may not regret being outvoted in certain cases.

This Article 30, as of 1907, has now been in force 21 years, and has been the basis for an extensive amount of type designations. To my mind it was one of the most constructive pieces of nomenclatorial legislation ever accomplished.

Self-understood, Article 30 does not meet with 100% of the views of 100% of the zoologists and several attempts have been made to modify it. Thus in 1913, and 1927 it was proposed to the Commission that Recommendation on "elimination" be changed from a "recommendation" to a "rule", but the proposition was not carried. This same proposition has been resubmitted to the Commission for reconsideration at its 1930 meeting in Italy. It reads as follows: —

Add to Art. 30 (e) of the Rules of Nomenclature [The following species must not be selected as the type of a genus]:

(δ) Species which have already been removed ("eliminated") from the genus. It also constitutes elimination: if the eliminated species have later been restored to the genus; if they are removed only with doubts, conjecturally, with reservation; if they are transferred to another genus already existing before; if on this occasion they are named differently than by the author of the original genus; if the genus is expressly restricted to a definite part of the species originally contained in it, even if the author does not say where the rest of these belong. On the other hand it does not constitute elimination: if an author only says that certain species possibly, perhaps, probably, belong to a certain other unit, but de facto does not remove them from the former genus; if he simply under a genus mentions only a part of its original species; if he removes all the species of a genus still available as type to one other genus. And if species are removed from a genus or beyond its limits new species are created, which are identical with other species contained in it, this constitutes no elimination of the latter.

The application of the above-said principle is subject to the following rules: 1. Forms not named in a manner having standing in nomenclature are yet to be taken into consideration. 2. If all species still available as type have been or would have to be eliminated simultaneously and the valid name of one or more of the genera to which such have been or would have to be transferred, is younger than that of the original genus, this latter one has to take the place of the youngest of them. If there are several such youngest names (thus coeval [coequal?] among themselves), the eliminating author or, if he has omitted to do so, the first revising one has to decide in the place of which of these the name of the original genus is to be used. If the youngest of those names is or are of the same date as that of the latter, the eliminating author has to decide whether the latter is to be substituted for the youngest or one of the youngest and for which of them, or not. If, however, the valid name of none of the genera to which species of the genus in question have been or have to be removed, is younger or of the same date as that of the latter, this name becomes a partial synonym of the name of each of the first-mentioned genera. 3. If a genus has been divided into subgenera and one of them is expressly or by using the generic name for it designated as typical by the original or a following author, this is considered as an elimination of the other original species of the genus. 4. If a part of the original species of a genus is eliminated and in a simultaneous publication one of them is designated as type, such a designation of type is invalid. Strike out Recommendation (k), which is irrelevant in consequence of the above.

1912. — After extensive correspondence with American systematic entomologists, Banks & Caudell (1912) published "The Entomological Code" in regard to which they state: —

The result, while hardly satisfactory to any one entomologist, expresses the opinion of systematic workers far more accurately *) than the vote of any committee.

*) The validity of this statement is not self-evident. The joint authors were a committee of two; in just how far their agreements (i. e. votes by two persons) express a situation more accurately than the agreements (i. e. votes) reached by larger committees is not entirely clear.

In respect to type species they adopt the following rules: —

93. In every genus there shall be one species known as the type, or genotype. Two essential qualifications of a genotype are: 1st. It shall have a valid name. 2d. That name shall have been originally included without question in the genus.

94. No specific name originally quoted in synonym in a certain genus can be accepted as the type of that genus, nor one doubtfully determined, provided there are others available for type citation under these rules.

95. Genera with but one originally included specific name (exclusive of synonyms and subspecies or varieties) are monobasic and genera with more than one such name, not including synonyms, are polybasic.

96. The genotype of a monobasic genus is the only specific name cited, irrespective of misidentification or restriction.

Example. — *Alpha* Smith, new genus with a single specific name included, the *Beta alba* of Jones. Then *Beta alba* Jones is the genotype of *Alpha* Smith, even if it later results that Smith did not know that species, what he thought to be that being in reality a very different species.

97. In regard to the genotypes of polybasic genera the following rules apply:

a. When an author, in describing a new genus, mentions or refers to any valid specific name, except one doubtfully included or quoted in synonymy, as type, typus, genotype, &c., or states that the genus is "based on" or "erected for" (or such similar phrase) some one species, then the species properly represented by that specific name is the genotype, irrespective of misidentification.

b. If a specific name not originally included in the genus, but with an orginally included species quoted in synonymy, is designated as the genotype of an established genus, such designation is deemed valid for the species in synonymy.

Etample. — *Alpha* Smith 1870, based on two new species, *alba* and *nigra*. In 1880 the genotype is designated as "*brunnea* Jones 1860 (= *nigra* Smith 1870)". Then, by the above rule, *nigra* Smith 1870 is the properly designated type of *Alpha*.

c. If a genus, established in the text, is also given on a previous page in a synoptic table with the mention of a valid specific name or names, the type is not thereby selected or restricted.

98. If the author of a polybasic genus has not established the genotype by any of the above methods, it may be selected by any one as follows:

a. The first author to select as type one of the originally unquestionably included, specific names fixes the genotype, provided such specific name has not already been properly chosen as the type of another genus, and such selected specific name represents the type, irrespective of misidentification.

b. If all the originally unquestionably included species of a genus are already properly selected as types of other genera, any one of them may be chosen as the type of this genus.

99. A specific name cited as the genotype with a query, or indicated as the probable type, is not thereby the type.

100. If two or more species are cited at one place as types of one genus, neither is thereby the type, nor is type selection restricted.

101. If all but one of the species of a polybasic genus are types of other genera, then that one remaining, if otherwise eligible, is the genotype.

102. If all but one of the species of a polybasic genus are removed to other genera, but not as types, this one remaining does not thereby become the genotype — that is, an author does not restrict a genus except by type selection.

Example. — *Alpha* is established with four included species, none cited as type. Later species 1, 2, and 4 are removed to the genus *Beta*, but none of them as its genotype. Species 3, the only one not removed from *Alpha*, is not thereby the type of *Alpha*, and no more eligible for type selection than species 1, 2, or 4.

103. The citation of a generic name in synonymy under another generic name does not thereby restrict either name.

Example. — *Alpha* is described with four originally included species. Later *Beta* is described with *Alpha* quoted in synonymy, and with the species 1 and 2 included. This does not restrict *Alpha* to the species 1 and 2.

104. When an author changes a generic name, or unites two or more genera, the genotypes remain unchanged.

105. The type of a new generic name which by sign or language is clearly shown to be proposed to replace another valid generic name, is the same as that of the genus replaced.

106. If a polybasic genus without designated genotype contains among its originally unquestionably included species one not in synonymy and of the same name as the generic name, then that species is the genotype (type by absolute tautonomy).

107. Genotypes fixed according to the above rules are stable, and cannot be changed. No other form of genotype designation than distinctly indicated above shall be valid; therefore the use of "n. gen. n. sp.", "sensu stricto", the repetition of generic characters in the specific description, the first species, the most common species, a medicinal species, a figured species, nor one with the life history given shall, of itself, be considered as genotype fixation.

Über die Anwendung der Linien-Abschätzung bei der Frequenzbestimmung von Forstinsekten.

Professor Uunio Saalas, Helsinki, Suomi, (Finnland).

Bekanntlich ist in letzter Zeit der exakten Bestimmung der Frequenz von Tieren und Pflanzen eine immer mehr und mehr zunehmende Beachtung geschenkt worden. In der Botanik ist man in dieser Beziehung schon recht weit gekommen und auch in der Zoologie ist bereits ein guter Anfang gemacht worden. Es genügt hier beispielsweise ein bloßer Hinweis auf die quantitativen Abschätzungsmethoden bei Wassertieren oder auf die Versuche, die Anzahl von auf einem bestimmten Gebiete nistenden Vögeln abzuschätzen.

Auch auf dem Gebiete der Entomologie wurden verschiedene Versuche zu einer objektiven Bestimmung der Insektenfrequenz gemacht, und hat man es dabei mit der Anwendung der verschiedensten Methoden versucht. Doch eignen sich bei weitem nicht immer dieselben Methoden in allen Fällen. Die zahlreiche Menge der Insekten, ihre Kleinheit, verborgene Lebensgewohnheiten, Beweglichkeit, ungleichmäßige Verbreitung, verschiedenes Auftreten zu verschiedenen Jahreszeiten u. s. w. stellen of sehr große Schwierigkeiten in den Weg.

Nichtsdestoweniger war es möglich, mehrere Methoden ausfindig zu machen, die sich vorzüglich je für die einzelnen Fälle eignen, und die der Wissenschaft allem Anschein nach sehr gute Dienste geleistet haben. Es verbietet sich von selbst, im Rahmen dieser gedrängten Darstellung, eine erschöpfende Beschreibung der verschiedenen Methoden, geschweige denn eine Art historischen Ausblicks über die Erfinder derselben zu geben. Ich will nur in Kürze auf einige dieser Verfahren hinweisen, welche bei der Frequenzbestimmung von Insekten in Anwendung kommen.

So bedarf es beispielsweise, um sich einen einigermaßen genauen Begriff von der Frequenz der am Boden, unter der Moosdecke und unter gefallenem Laub lebenden Insekten zu machen, nur der Auswahl von Quadraten eines bestimmten Umfangs, auf denen die daselbst sich befindenden Insekten gezählt werden; oder, wenn es sich um kleinere, schwerer zu unterscheidende Insekten handelt, lassen sich Fangvorrichtungen anwenden, in die die Streu einer gewissen Fläche eingesammelt wird, und deren bekannteste der Apparat von Tullgren sein dürfte.

Bei weitem schwieriger gestaltet sich schon eine, wenn auch nur einigermaßen exakte Bestimmung von den beweglichen Insekten. So wurde der Versuch gemacht, die Frequenz von Schmetterlingen, Libellen u. a. derart zu bestimmen, daß auf einem Gebiet von einem gewissen Umfang die Insekten einfach zusammengezählt wurden (etwa in gleicher Art wie bei der Frequenzbestimmung von Vögeln). Nach einer anderen Methode fängt man die Insekten im Verlauf einer gewissen Zeit an verschiedenen Stellen mit ein und derselben Fangvorrichtung und zählt dann die Individuen zusammen.

Hinsichtlich der Bestimmung und Darstellung der Frequenz von unter der Rinde lebenden Insekten möchte ich vor allem auf die Untersuchungen

des Russen Golojanko und speziell des Schweden Trägårdh hinweisen, deren interessante Resultate u. a. auf dem III. Internationalen Kongress in Zürich im Jahre 1925 von letzterem dargestellt wurden. Bekanntlich stellt Trägårdh vollständige „Analysen" von abgestorbenen Bäumen auf, die er auf an den verschiedenen Teilen des Stammes und der Äste gefundenen verschiedenartige Käfer gründet. Als Resultat seiner Untersuchungen stellt er von einem jeden von ihm untersuchten Baum je ein schematisches Bild dar, durch welches man auf den ersten Blick einen anschaulichen Begriff davon erhält, welche Teile des Baumes je von welchem Insekt angegriffen sind. Ferner gelangte Trägårdh, auf Grund dieser seiner „Analysen" zur Einsicht darüber, in welcher Reihenfolge die einzelnen Arten die Bäume angegriffen hatten. Außer durch schematische Figuren, stellt Trägårdh — ebenso wie auch Golojanko — die Resultate seiner Analysen auch in anschaulichen Diagrammen dar.

Wenn ich nun im folgenden einige von mir behufs Bestimmung der Frequenz von Forstinsekten in Suomi (Finnland) benutzte Methoden beschreibe, so will ich gleich anfangs betonen, daß ich diese Methoden keineswegs an Stelle der Trägårdh'schen Analysen setzen will. Ich hege vielmehr die Überzeugung, daß sie neben und gleichzeitig mit dem Trägårdh'schen Verfahren von gewissem Nutzen sein dürften. Sie erfüllen je für sich einen bestimmten Zweck.

Die Analysen von Trägårdh stellen die je an einem einzigen Baume gefundenen Insekten dar. Die Aufstellung derselben beansprucht ohne Zweifel eine recht lange Zeit und setzt von jedem einzelnen Baume ein Bild oder Diagramm für sich voraus. Die von mir benutzte Methode, mit der ich seit dem Jahre 1916 gearbeitet habe, ermöglicht eine Feststellung der Frequenz der Insekten auf größere Waldstrecken, kann also infolgedessen auch nicht annähernd so genau und bis in die Einzelheiten gehend sein wie das Trägårdh'sche Verfahren. Indessen besitzt sie den Vorzug, daß es mit ihrer Hilfe möglich ist, sich einen annähernd richtigen Begriff von den Waldinsekten eines weit ausgedehnten Gebietes zu machen und in einigermaßen gedrängter Form ein objektives Gesamtbild von demselben zu geben.

Das von mir benutzte Verfahren gründet sich auf die sog. Linienabschätzung. Bei uns in Finnland kommt die Linienabschätzungsmethode bei forstwissenschaftlichen Untersuchungen zu den mannigfaltigsten Zwecken in Anwendung. Sie ist ganz besonders zweckmäßig in einem Lande, wo sehr weit ausgedehnte Waldgebiete vorkommen, und wo, wie bei uns, die Forstwirtschaft ein relativ extensives Gepräge hat. Als Beleg für den Erfolg einer derartigen Abschätzungsmethode mag erwähnt sein, daß in Finnland neuerdings auf Initiative des Herrn Prof. A. K. Cajander und unter Leitung des Herrn Prof. Yrjö Ilvessalo eine Abschätzung des allgemeinen Zustandes der Wälder durchgeführt worden ist, indem quer durch das Land von SW zu NO 39 Parallelen gezogen wurden, deren zusammengenommene Länge nahezu 13 000 km betrug und sämtliche an diesen Linien vorkommender Wald genau untersucht wurde.

Diese Idee machte ich mir bei der Abschätzung der Frequenz von Forstinsekten in einigen Bezirken zunutze. So untersuchte ich im Sommer 1916 mit Hilfe einer derartigen Linienabschätzung 16 Waldgebiete — vor-

zugsweise durch Borkenkäfer *(Ipidae)* arg geschädigt —, deren Umfang etwa 3200 ha betrug.

Ich zog einige, aufs Geratewohl gewählte Linien über das zu untersuchende Gebiet. Je zahlreicher die gezogenen Linien, um so zuverlässigere Ergebnisse werden natürlich erzielt. Doch ist keine allzugroße Anzahl derselben erforderlich, um ein einigermaßen getreues Bild vom Gebiet zu erhalten, speziell, wenn dieses keine allzugroße Variabilität erbietet. Die zusamengerechnete Länge der von mir genauer untersuchten Linien betrug in den betreffenden Gebieten etwa 27 900 m. Darauf wurden auf diesen Gebieten, längs dieser Linien, deren Breite 2 m betrug, jeder einzelne Baum, der in Brusthöhe mindestens 6 cm dick war, und zwar sowohl lebende als auch abgestorbene (kürzlich oder alte verdorrte, mehr oder weniger morsche), liegende Bäume, Stümpfe, die Dicke des Baumes, der Waldtypus usw. vermerkt. Die an jedem Baume angetroffenen Insekten wurden annotiert. Derartige Notizen setzen allerdings beim Forscher eine gründliche Kenntnis der Insekten der betreffenden Gegend und der Fraßbilder der einzelnen Arten voraus.

Behufs Darstellung der Frequenz der gängebohrenden in oder unter der Rinde, sowie im Bauminnern lebenden Insekten, bediente ich mich folgender Skala:

I Nur ein Fraßbild oder ganz vereinzelte Fraßbilder.
II Die Fraßbilder bedecken bedeutend weniger als die Hälfte des in Frage stehenden Baumes oder Baumteiles.
III Die Fraßbilder bedecken etwa die Hälfte des in Frage stehenden Baumes oder Baumteiles.
IV Die Fraßbilder bedecken bedeutend mehr als die Hälfte des in Frage stehenden Baumes oder Baumteiles.
V Die Fraßbilder bedecken beinahe vollständig den in Frage stehenden Baum oder Baumteil.

Die die Frequenz der einzelnen Arten bezeichnenden Zahlen beziehen sich auf deren Menge in demjenigen Baumteile, in dem sie unter normalen Verhältnissen leben. Bezeichne ich also die Frequenz von *Pityogenes chalcographus* an einem beliebigen Baume mit V, so ist darunter zu verstehen, daß dieser Käfer, wenn der Baum klein und dünnrindig ist, denselben völlig, wenn der Baum jedoch groß ist, nur den dünnrindigen Wipfel und die Zweige desselben erobert hat. Ist hingegen der Grad seiner Frequenz nur III, so bedeutet das, daß bei einem kleinen Baume etwa die Hälfte, bei einem großen dagegen etwa die Hälfte des Wipfelteiles (also n i c h t des ganzen Baumes) von dem Insekt befallen ist usw.

Um absolute Gewißheit über sämtliche, an stehenden Bäumen lebenden Arten zu erhalten, müssen natürlich die auf den Linien stehenden, von den Insekten befallenen Bäume gefällt und mehr oder weniger sorgfältig abgerindet werden. Und im allgemeinen dürfte es sich leicht entscheiden lassen, zu welcher Frequenzgruppe je eine Insektenart zu rechnen ist. Dies gilt jedenfalls für die zu den Gruppen II—V gehörenden Arten. Dagegen bedarf es einer recht großen Umsicht, damit nicht etwaige zu Gruppe I gehörende Arten übersehen werden.

Auf Grund von derartig erhaltenen Linienprotokollen lassen sich daran verschiedene Tabellen ausarbeiten, welche die Frequenz der Insekten in den untersuchten Gebieten beleuchtete.

Im folgenden erlaube ich mir einige Beispiele zu dem eben Gesagten anzuführen.

Folgende Tabelle stellt die Frequenz von Borkenkäfern an stehenden verdorrten Fichten *(Picea excelsa)* auf einem von mir untersuchten, 60 ha großen Verheerungsgebiete dar.

I. — Stehende abgestorbene Fichten.

	Frequenz	Stärkegrad der Bäume in Brusthöhe, cm								Im Ganzen
		7—10	11—15	16—20	21—25	26—30	31—35	36—40	41—45	
		Prozentzahlen der Bäume								
Hylurgops palliatus	0	100	100	33	50	33	33	17	—	41
	II	—	—	—	—	—	—	33	100	9
	III	—	—	—	20	—	—	17	—	9
	IV	—	—	67	30	67	67	33	—	41
Polggraphus sp. (hauptsächlich *subopacus* u. *polygraphus*)	0	—	100	33	70	67	100	83	—	66
	I	—	—	—	—	33	—	—	—	6
	II	—	—	33	10	—	—	17	100	13
	III	—	—	34	10	—	—	—	—	6
	IV	50	—	—	10	—	—	—	—	6
	V	50	—	—	—	—	—	—	—	3
Crypturgus hispidulus	0	100	100	100	100	83	100	100	100	97
	I	—	—	—	—	17	—	—	—	3
Xyloterus lineatus	0	100	100	100	40	33	33	17	100	47
	III	—	—	—	30	33	—	17	—	19
	IV	—	—	—	20	17	33	33	—	19
	V	—	—	—	10	17	34	33	—	15
Dryocoetes autographus	0	100	100	100	100	100	67	83	100	94
	I	—	—	—	—	—	—	17	—	3
	II	—	—	—	—	—	33	—	—	3
Pityogenes chalcographus	0	100	100	67	80	83	100	100	100	88
	I	—	—	33	10	17	—	—	—	6
	V	—	—	—	10	—	—	—	—	6
Ips typographus	0	100	—	—	30	33	—	17	—	25
	II	—	—	—	20	—	33	33	100	19
	IV	—	—	33	10	—	—	17	—	9
	V	—	100	67	40	67	67	33	—	47
Ips duplicatus	0	100	100	100	100	100	67	100	100	97
	I	—	—	—	—	—	33	—	—	3
Rhagium inquisitor	0	100	—	67	50	67	67	67	—	59
	I	—	—	33	—	—	—	—	100	6
	II	—	100	—	40	33	33	33	—	31
	III	—	—	—	10	—	—	—	—	3
Tetropium sp. (*luridum* u. *fuscum*)	0	100	100	67	60	66	67	50	—	62
	II	—	—	—	30	—	33	17	100	19
	III	—	—	33	10	17	—	33	—	16
	V	—	—	—	—	17	—	—	—	3
Callidium coriaceum	0	100	100	100	90	100	100	100	100	97
	III	—	—	—	10	—	—	—	—	3
Monochamus sp.	0	100	100	33	100	100	100	100	100	94
	I	—	—	33	—	—	—	—	—	3
	II	—	—	34	—	—	—	—	—	3
Pytho depressus	0	100	100	100	100	100	100	83	100	97
	III	—	—		—	—	—	17	—	3
Anobium Thomsoni	0	100	100	100	100	83	100	100	100	97
	II	—	—	—	—	17	—	—	—	3

Die linksstehenden römischen Ziffern beziehen sich auf den Frequenzgrad, die arabischen wiederum auf die Prozentzahl der verschieden dicken Bäume. Rechts befindet sich eine Zusammenstellung sämtlicher Bäume. So können wir z. B. ablesen, daß *Ips typographus* an 75 % der Bäume und zwar an 47 % als absolut dominierendes Insekt vorkommt. Sehr zahlreich vertretene Borkenkäfer waren ebenfalls *Hylurgops palliatus, Polygraphus (subopacus* und *polygraphus)* und *Xyloterus lineatus.* Unter den Bockkäfern waren *Rhagium inquisitor* und nach ihm *Tetropium* die am meisten verbreiteten Arten.

Die nächstfolgende Tabelle wiederum zeigt die Insektenfrequenz in von mir auf einem 236 ha großen Gebiete untersuchten, vom Sturme gefällten Fichten.

II. Liegende Fichten.

	Frequenz	%
Hylurgops glabratus	o	88
	I	6
	III	6
Hylurgops palliatus	o	70
	III	12
	IV	12
	V	6
Polygraphus sp. (hauptsächlich *punctifrons*)	o	59
	I	6
	II	6
	III	23
	V	6
Pityogenes chalcographus	o	59
	II	6
	III	6
	V	29

	Frequenz	%
Ips typographus	o	41
	I	6
	III	12
	V	41
Rhagium inquisitor	o	94
	II	6
Tetropium sp.	o	76
	I	6
	II	6
	III	12
Monochamus sp.	o	82
	II	6
	III	6
	IV	6
Pogonochaerus fasciculatus	o	94
	I	6

Links steht der Frequenzgrad, rechts die Prozentmenge der Bäume, an denen die verschiedenen Insekten in verschiedener Menge gefunden wurden. Auch hier ist *Ips typographus* der am meisten verbreitete Käfer. Dann folgen *Pityogenes chalcographus* und *Polygraphus* sp. (vor allem *punctifrons).*

Die dritte Tabelle enthält die auf einem $3^1/_2$ ha großen Abholzungsgebiete an frischen Fichtenstümpfen angetroffenen Käfer.

III. Fichtenstümpfe

	Frequenz	%
Hylurgops palliatus	o	97
	I	3
Crypturgus hispidulus	o	94
	I	3
	II	3

	Frequenz	%
Dryocoetes autographus	o	23
	I	10
	II	26
	III	15
	IV	21
	V	5
Hylobius abietis	o	94
	I	3
	II	3
Rhagium inquisitor	o	90
	I	8
	IV	2

Die hier ohne Frage am häufigsten auftretende Art war *Dryocoetes autographus.*

Die beiden folgenden Tabellen enthalten die Zusammenstellung eines 25 ha und eines zweiten, $3^1/_2$ ha großen Kiefernwaldes, an dessen frischen Stümpfen ich Käfer beobachtete.

IV. Kiefernstümpfe.

	Frequenz	%
Blastophagus piniperda	o	16
	I	37
	II	5
	III	21
	IV	16
	V	5
Hylastes cunicularius	o	95
	I	5
Hylastes opacus	o	90
	II	5
	III	5
Ips suturalis	o	95
	I	5

V. Kiefernstümpfe.

	Frequenz	%
Blastophagus piniperda	o	86
	II	7
	III	7
Hylastes ater	o	86
	I	7
	III	7
Hylobius sp.	o	86
	I	14
Rhagium inquisitor	o	80
	I	6
	II	7
	III	7
Tetropium sp.	o	93
	I	7
Acanthocinus aedilis	o	46
	II	20
	III	7
	V	27

Auf ersterem Gebiet dominierte *Blastophagus piniperda,* auf letzterem *Acanthocinus aedilis.*

Hat man sich erst an eine Ablesung derartiger Tabellen gewöhnt, so dürfte man eine einigermaßen richtige objektive Vorstellung von der Insektenfrequenz in den betreffenden Gebieten erhalten.

Die je für sich untersuchten Gebiete erlauben dann Zusammenstellungen zu machen. Ich lasse als Beispiel hierfür einige solche folgen.

VI. — Stehende abgestorbene Fichten.

Untersuchungsgebiet	1	2	3	4	6	7	8	10	11	12
Grösse (Ha)	1.750	236	60	150	1,5	2,5	—	6,5	5	525
% abgest. Fichten	7	15	22	9	68	19	13	46	57	77
Ipidae:	%									
Ips typographus	68	49	75	48	81	75	25	4	50	—
Polygraphus sp.	21	38	34	52	—	25	75	23	50	10
Pityogenes chalcographus	13	6	13	22	24	—	25	73	—	50
Hylurgops palliatus	26	44	59	26	5	8	50	12	—	10
Xyloterus lineatus	21	35	53	30	33	8	50	4	—	—
Crypturgus sp.	5	3	3	4	14	8	—	4	—	—
Xylechinus pilosus	8	4	—	—	—	—	—	8	—	—
Ips suturalis	—	—	—	—	5	8	—	—	—	—
Dryocoetes autographus	—	—	6	—	—	—	—	4	—	—
Phthorophloeus spinulosus	—	—	—	—	—	—	—	4	—	—
Pityophthorus fennicus	—	—	—	—	—	—	—	4	—	—
Ips proximus	—	—	—	—	—	—	—	4	—	—
Ips duplicatus	—	—	3	—	—	—	—	—	—	—
Cryphalus saltuarius	—	3	—	—	—	—	—	—	—	—
Cerambycidae:										
Tetropium sp.	50	32	38	44	24	8	—	—	25	—
Rhagium inquisitor	42	34	41	22	19	42	—	12	—	—
Monochamus sp.	3	4	6	—	5	8	—	—	25	—
Callidium coriaceum	—	17	3	—	—	17	25	—	—	—
Pogonochaerus fasciculatus	—	3	—	4	—	—	—	4	25	—
Semanotus undatus	3	1	—	—	—	—	—	—	—	—
Callidium sp.	—	—	—	17	—	—	—	—	—	—
Leptura sp.	—	—	—	—	—	8	—	—	—	—
Caenoptera minor	—	1	—	—	—	—	—	—	—	—
Curculionidae:										
Pissodes harcyniae	3	7	—	13	5	8	—	—	25	—
Anobiidae:										
Ernobius explanatus	—	3	—	—	—	8	—	8	—	—
Anobium Thomsoni	—	10	3	—	—	—	—	—	—	—
Anobium emarginatum	3	1	—	—	—	—	—	—	—	—
Anobium sp.	—	—	—	9	—	—	—	—	—	—
Buprestidae:										
Anthaxia 4-punctata	3	—	—	—	—	—	—	—	—	—
Melanophila acuminata	—	—	—	—	—	—	—	12	—	—
Pythidae:										
Pytho depressus	—	4	3	9	—	—	—	—	—	—
Bostrychidae:										
Stephanopachys substriatus	—	—	—	—	—	—	—	4	—	—
Lymexylidae:										
Hylecoetus sp.	—	—	—	—	—	—	—	4	—	—
Siricidae (Hymenopt.):										
Sirex sp.	—	—	—	—	—	—	—	15	25	—

Die vorstehende Tabelle enthält Käfer an stehenden abgestorbenen Fichten aus 10, mit derartigen Bäumen bestandenen, genauer untersuchten Gebieten. Sie gibt, meiner Ansicht nach eine einigermaßen zutreffende Vorstellung von der relativen Frequenz der gewöhnlichsten gängebohrenden Käfer an stehenden Fichten in Süd- und Mittelfinnland.

Die erste Zifferreihe bezieht sich auf die fortlaufende Ordnungsnummer der untersuchten Gebiete, die zweite auf den Umfang des Gebietes in ha, die dritte auf den Prozentsatz der verdorrten von alten, stehenden, mindestens 6 cm dicken Fichten. In dieser Tabelle wurde nicht der Frequenzgrad der einzelnen Bäume vermerkt, sondern ausschließlich angegeben, in wieviel Prozent der verdorrten Bäume die verschiedenen Insektenarten angetroffen wurden.

Die Tabelle enthält die Insekten der einzelnen Familien in verschiedenen Gruppen dargestellt. In bei weitem größten Maße sind die Borkenkäfer *(Ipidae)* und von diesen vor allem folgende Arten vertreten: *Ips typographus, Polygraphus* sp. *(subopacus* und *polygraphus), Pityogenes chalcographus, Hylurgops palliatus* und *Xyloterus lineatus.* In zweiter Reihe kommen dann die Bockkäfer *(Cerambycidae)* und unter diesen haben ohne Zweifel *Tetropium* sp. *(luridum* und *fuscum)* sowie *Rhagium inquisitor* den Vorrang. Von den Rüsselkäfern *(Curculionidae)* kam nur eine Art *(Pissodes harcyniae)* vor.

Ferner finden wir im Verzeichnis Vertreter der Käferfamilien *Anobidae, Buprestidae, Pythidae, Bostrychidae* und *Lymexylidae* und von der Hymenopterenfamilie *Siricidae,* wenn schon sich diese im Vergleich zu den erstgenannten in bei weitem geringerer Menge finden lassen.

VII. — Liegende Fichten.

	1	2	3	4	6	7
Ipidae:	%					
Ips typographus	40	59	17	25	65	68
Pityogenes chalcographus	10	41	—	—	35	42
Polygraphus sp.	20	41	—	25	—	11
Hylurgops palliatus	5	29	—	25	—	—
Hylurgops glabratus	10	12	17	—	—	—
Xyloterus lineatus	—	—	—	25	4	—
Crypturgus sp.	10	—	—	—	—	—
Dryocoetes hectographus	5	—	—	—	—	—
Cerambycidae:						
Monochamus sp.	30	18	—	—	44	16
Tetropium sp.	25	24	17	25	9	5
Rhagium inquisitor	15	6	17	—	—	11
Pogonoekaerus fasciculatus	—	6	—	—	9	11
Callidium coriaceum	5	—	—	—	—	—
Curculionidae:						
Pissodes harcyniae	—	—	—	—	9	11
Pythidae:						
Pytho kolvensis	5	—	33	25	—	—
Pytho depressus	—	—	33	25	—	—
Pytho abieticola	5	—	17	—	—	—

Desgleichen nehmen an liegenden Fichten, über deren Käferwelt die vorstehende Tabelle Aufschluß gibt, und die bedeutend ärmer an Arten sind, ebenfalls die Borkenkäfer den ersten Platz ein.

Auch hier müssen als die Hauptarten *Ips typographus, Pityogenes chalcographus, Polygraphus* sp. und *Hylurgops palliatus*, und neben diesen auch noch *Hylurgops glabratus* genannt werden. Als die wichtigste *Polygraphus*-Art an gefällten Fichten muß jedoch *P. punctifrons* hervorgehoben werden, obschon dies aus der Tabelle nicht hervorgeht, denn es war mir speziell bei Beginn meiner Arbeit noch nicht möglich, die verschiedenen *Polygraphus*-Arten und die von ihnen gebohrten Gänge mit Sicherheit voneinander zu unterscheiden. Der, an stehenden Bäumen eine große Rolle spielende *Xyloterus*, kommt an liegenden Bäumen nur äußerst selten vor.

Von den, an liegenden Fichtenstämmen lebenden *Cerambyciden* sind die technisch so überaus schädlichen *Monochamus*-Arten (vor allem *sutor)* am reichlichsten vertreten. Dann folgen die *Tetropium*-Arten und *Rhagium inquisitor*, die ebenfalls an stehenden Bäumen vorkommen. Die *Curculioniden* sind von nur geringer Bedeutung; um ein weniges häufiger lassen sich (an älteren, bereits etwas angefaulten Stämmen) die *Pytho*-Arten finden.

An Fichtenstümpfen, auf welche sich die nun folgende Tabelle bezieht, ist *Dryocoetes autographus* der allgemeinste Borkenkäfer; dann folgt *Xyloterus lineatus. Ips typographus* kommt nur nachfraßfressend, niemals brütend vor. Von den Bockkäfern dürfte *Rhagium inquisitor* der verbreiteste sein, doch auch die *Tetropium-Arten* kommen recht häufig vor.

VIII. — Fichtenstümpfe.

	1	3	4	6	7	8	12	21a	21b
	%								
Ipidae:									
Dryocoetes autographus	4	33	11	11	—	—	50	77	12
Xyloterus lineatus	6	—	—	22	9	—	—	—	12
Hylurgops palliatus	5	—	—		—	8	—	3	—
Ips typographus (Nachfraß)	7	—	—	—	9	8	—	—	—
Ips laricis	—	—	—	—	—	—	—	—	13
Crypturgus hispidulus	—	—	—	—	—	—	—	5	—
Cerambycidae:									
Rhagium inquisitor	11	56	33	44	18	23	—	10	—
Tetropium sp.	5	11	—	—	9	8	—	—	—
Curculionidae:									
Hylobius sp.	—	—	—	—	—	—	—	5	—

Ähnliche Tabellen, wie die hier auf die Fichte bezogenen, können natürlich auch in bezug auf andere Baumarten angeführt werden; allein gestattet die beschränkte Zeit mir nicht, hier näher auf sie einzugehen. Anstattdessen will ich nur noch kurz darauf hinweisen, daß die Linienabschätzung mir nicht nur bei der Klarstellung der Frequenz von unter der Rinde und im Holzkörper lebenden Käfern von Nutzen war, sondern daß ich ebenfalls versuchte, diese Methode auch bei der Frequenz-

bestimmung von, die Baumkronen irgendwie deformierenden Insektenarten anzuwenden. Hierbei benutzte ich bei einer okulären Abschätzung der Bäume folgende Frequenzskala:

I Nur an ganz vereinzelten Ästen (bis unten an die Wurzel hin deutlich wahrnehmbare) Schädigungen zu bemerken.

II Mehrere, doch bei weitem nicht jeder zweite Ast durch Insekten deformiert.

III Etwa jeder zweite Ast durch Insekten deformiert.

IV Bedeutend mehr als jeder zweite Ast durch Insekten deformiert.

V Beinahe sämtliche Äste durch Insekten deformiert.

Bei einer derartigen okulären Abschätzung spielt selbstredend die Subjektivität eine bei weitem größere Rolle als bei einer Abschätzung, wie sie im vorigen für am Stamme lebende Insekten beschrieben wurde. Ich bin jedoch der Ansicht, daß man auch bei der Abschätzung der Beschädigungen der Kronen zu einem verhältnismäßig befriedigenden Resultat gelangen kann. Bei der Ausführung einer solchen Abschätzung waren mir zwei Assistenten behilflich und versuchten wir es mehrmals, jeder für sich, ein und denselben Baum zu taxieren, wobei sich unsere Resultate meist deckten. Nur selten und dann meist in Fällen, wo es sich um Bäume am Übergang aus einer Gruppe in die benachbarte handelte, fiel die Klassifizierung verschieden aus. Folgende Tabelle gibt eine Vorstellung von dem, durch *Blastophagus*arten *(piniperda* und *minor)* angestifteten Schaden in vier Kiefernwäldern.

IX. — Kiefernwälder.

		12	13	14	15
	Ha	525	7,5	46	85
		%			
Blastophagus	0	45	28	42	15
	I	20	33	28	23
	II	20	17	11	28
	III	11	19	14	21
	IV	3	3	5	11
	V	1	—	—	2

Wie ersichtlich, war insbesondere der letzte Kiefernwald, wo der Prozentsatz der einigermaßen gesunden Bäume nur auf 15 % stieg, durch *Blastophagus* schwer geschädigt, doch auch andererorts war die Schädigung recht bedeutend.

Zum Schlusse mag noch eine Tabelle vorgewiesen werden, auf welcher eine, durch die Forleule *(Panolis griseovariegata)* angerichtete Verheerung in einem im südöstlichen Finnland belegenen Kiefernwalde im Sommer 1925 oder ein Jahr, nachdem dieser Schmetterling in Mitteleuropa seine bekannten Schädigungen angerichtet hatte, verzeichnet ist. Das in Frage stehende am ärgsten geschädigte Gebiet war ca. 100 ha groß. Ich untersuchte sämtliche, an zwei, quer durch diesen Wald laufenden Linien wachsende Bäume. Das Resultat gestaltete sich folgendermaßen:

X. — Kiefernwald.

		1	2
		%	
Panolis griseovariegata	0	—	—
	I	2	2
	II	7	4
	III	13	8
	IV	41	48
	V	37	38

Die der Klasse V angehörenden Bäume waren allem Anschein nach unwiderruflich verloren (etwa 37—38 %). Die übrigen hätten sich, vorausgesetzt, daß keine weitere "Hilfe" wie z. B. durch den Waldgärtner *(Blastophagus)* hinzugekommen wäre, eventuell Stand halten können; im folgenden Sommer trafen jedoch die letztgenanten ein und die Bäume in dem betreffenden Walde mußten samt und sonders d. h. etwa 20 000 St. Stockbäume und etwa 5,500 m^3 Brennholz und Bergwerkbalken gefällt werden. Etwa 30 ha mußten bar und der übrige Teil des Schädigungsgebietes in Besamungs-Stellung abgeholzt werden.

In gleicher Weise wie im vorausstehenden beschrieben wurde, kann die Linien-Abschätzung selbstverständlich auch bei der Frequenzbestimmung anderweitiger Waldschädiger — sowohl von an dem Stamme als auch an der Krone lebenden Arten — mit Erfolg benutzt werden.

The Selection of Family Names.

A. L. Melander, The College of the City of New York.

Stiles (1912) and Cabrera (1914) have both stated that after divided efforts at perfecting the Code of Nomenclature presented to the first four International Zoological Congresses, the Commission on Nomenclature, appointed in 1895, was instructed at the fifth Congress in Berlin, in 1901, to bring back only such a Code as it could unanimously agree upon. It was not until 1913 at the ninth Congress that the present Code was presented and accepted.

Article 4 of the Code states that the name of a family is to be formed by adding *idae* to the stem of the name of its type genus. Article 5 states that the name of a family is to be changed when the name of its type genus is changed. The rules, however, because of the impossibility of arriving at a unanimous decision, do not indicate how the type genus is to be determined. The law of priority, dealt with in Articles 25—29, concerns genera and species, but not families or groups of larger denomination.

Since the International Rules of Zoological Nomenclature fail to designate how the type genus of a family is to be selected, entomologists at well as other taxonomists are divided in the procedure they follow into several opposing schools, and their published views are so diverse as to indicate the impossibility of obtaining progress if it is limited to unanimity of opinon. Most systematists prefer to conserve the names in accepted usage, thus accepting as type genera long-recognized, usually dominant forms. Some entomologists would make the earliest described genus of each family its type genus, renaming the families after the oldest genus whenever necessary, or if that name is abandoned, after the next oldest. Some zoologists, fortified by Article 5, which authorizes the renaming of a family when the name of its type genus is changed, have incurred the ire of the conservationists by resurrecting long-forgotten generic names carrying with them changes in family designation. Still others would extend to family names the law of priority as applied to genera, without regard to permanence of family types. A few, disregarding the Code, would form family names after the fashion of Orders, not basing them upon type genera; e. g. Holmgren's Protermitidae, Mesotermitidae and Metatermitidae, for which there are no corresponding genera.

It is the old problem of stability of nomenclature applied to family names, aggravated by indecision as to what should constitute the type genus of a family, as well as what should constitute the limits of the family concept. To the conservationist it is a more serious matter to change the names of families of genera than it is to change the names of individual

genera, and certainly the vast number of general students and semi-professionals agree, since they use family names more than the names of genera or species.

At first thought stability of names would be attained by applying the law of priority to family names as well as to genera and species. Dr. G. Horváth (1912), at the eighth International Zoological Congress at Gratz, opposed the changing of family names at the whim of any systematist, and formulated the following addition to the rules relating to family names for submission to the Commission on Nomenclature: "The law of priority is to apply also to the nomenclature of families, subfamilies and other groups higher than the genus. All these categories should bear the oldest name given them, which name should be formed from a valid generic names included within that category". As far as I learn the Commission has not approved this proposal.

E. P. Van Duzee (1916) in a paper presented before the Entomological Society of America formulated several rules which guided him in the preparation of his Catalog of North American Hemiptera. He would consider all names which have been applied to a particular group and select the earliest which was based upon a genus, bringing it into accord with the rules by making it terminate in *idae.* The corresponding genus then becomes the type genus of the family.

Oberholser (1920) codified thirteen rules for the formation of family names and the selection of family types, basing his recommendations on the law of priority. He presents the following four objections to the automatic selection of the oldest generic name as family type:

a. The family name would be changed when any genus with an older name is added to the group.

b. The transfer of an older genus to another family would cause confusion by the corresponding transfer of the family name.

c. Its universal application would produce wholesale changes in nomenclature.

d. There would be no permanet concept of a family type.

Oberholser's rules are an extension of Van Duzee's and the entomological code of Banks and Caudell (1912), as follows. Lyon (1920) and Casey (1920) have both published approval of the first twelve rules and opposition to the thirteenth.

1. The name of a family is to be formed by adding the ending *idae* to the stem of the tenable name of its type genus.

2. The name of a subfamily is to be formed by adding the ending *inae* to the stem of the tenable name of its type genus.

3. Subfamily names shall for purposes of nomenclature be accorded the same treatment as family names.

4. The type genus of a family or subfamily must be one of its included genera.

5. The type genus of a family or subfamily is the included generic group from the name of which the family or subfamily name was originally formed, and is to remain the type genus irrespective of changes in its name.

6. A family or subfamily name formed from the name of an included genus is valid whether or not originally accompanied by a diagnosis, or by specific mention of the type genus.

7. The law of priority, subject to that of generic names, shall be fully operative in relation to family and subfamily names.

8. In the application of the law of priority, consideration is to be given to all names employed respectively in a family or subfamily sense; and to all supergeneric group names not higher than the grade of family, if based on an included genus; but any such names when brought into use must have their endings changed to *idae* or *inae* if they were originally proposed with other terminations.

9. When a family or subfamily is divided, its name is to be retained in both family and subfamily sense for that part containing the type genus of the original group. The remaining portion should take as its family or subfamily designation the earliest name based on any of its included genera. If there is no such name, the family or subfamily may take for its type genus any included genus, preferably the most characteristic or best known.

10. When a subfamily is raised to family rank, its type genus is to be retained as the type genus of such family group.

11. The family or subfamily formed by the combination of two or more families or subfamilies takes for its type genus the generic group in any of its components that was first made the basis of a family or subfamily name.

12. When for any reason the name of the type genus of a family must be changed, the dependent family name must be changed to correspond to the new designation of the type genus.

13. Of two family or subfamily names in zoology having exactly the same spelling, the latter is to be distinguished from the earlier by the prefix "Pro": hypothetical example, *Propicidae*.

The law of priority aims at ultimate stability of nomenclature, but if it is extended to family and subfamily names it brings about immediate confusion. No taxonomic group is less exactly bounded than the family. There is a growing tendency among specialists to divide and subdivide families, restricting the original name to smaller and smaller groups of genera. Many Linnaean genera, which in the past generation became families, are now being treated as superfamilies. In its limits *Musca* became the *Muscidae*, but now there are scores of families of calypterate *Muscidae* and scores of additional families of acalypterate *Muscidae*. Swinhoe divided the Noctuidae into thirty-six families. Limits have shrunk for the *Ichneumonidae*, *Sphecidae*, *Apidae*, *Scarabaeidae*, *Chrysomelidae*, *Cerambycidae*, *Tineidae*, etc., of the older entomologists.

In this changing process of family limitation, where is to be the starting point for the law of priority? The distinction between *idae*, *ites*, *ides* and *ata* as a family designation was unknown to the early zoologists, so such early names are equivalent to our present families in *idae*. Handlirsch, in applying the law of priority in Schroeder's Handbuch, rejects the early conflictingly formed names and selects the first name ending in *idae* for a family and in *inae* for a subfamily, thus making the starting point for his system of family nomenclature fifty years after the Systema

Naturae; and he lumps together in wholesale numbers the efforts of the splitters whose ideas of family, subfamily or tribal boundaries do not coincide with his.

McAtee (1921) has amply stated the difficulties arising from the impartial application of the law of priority to family names, one sentence from which may be quoted: As between a family or subfamily name in classical form and properly used, a scientific-appearing name casually used, a vernacular name appearing in an evidently good system, and a vernacular name simply in text, who is to be the arbiter? and who will accept his judgment? McAtee also pointed out that there would be fewer entomological casualties, if family names are based on the earliest named genus than if the uncharted multitude of family names be searched for priority.

H. H. Karny (1923) has stated that the oldest genus should always be the genus eponymum for a family, unless

a. it is a genus dubium,

b. or annectant between two families,

c. or when the resulting group name would be the same as an earlier name, e. g. *Dolichopoda* of the Orthoptera and *Dolichopus* of the Diptera would both form the *Dolichopodinae,*

d. or when the name of the oldest genus has been used in the newer literature for the name of a genus belonging to another group.

There is as yet no authorization for the mandatory selection of the earliest described genus as type for a family, other than the recommendation in the original Stricklandian Code of 1842, nor is there a precedent for this principle in the determination of genotypes. Its application has already brought on chaotic changes, as witnessed when Kirkaldy changed in the Hemiptera the *Pentatomidae* to the *Cimicidae,* the *Cimicidae* to the *Cacodmidae,* then later to the *Clinocoridae,* the *Coreidae* to the *Lygaeidae,* and the *Lygaeidae* to the *Myodochidae.*

Neither the extension of the law of priority to family names, nor the fixation of type genera by the oldest genus principle will stabilize the names of all so long as family names must be changed whenever the type genus is sunk in synonymy as provided by the International Code. In fact even more than in the case of genera the discovery of an ancient paper is likely to affect the names of families, because the earlier workers dealt largely with the dominant forms which have become the types of families. The resuscitation of Meigen's 1800 paper with the supposed identification of *Fungivora* for *Mycetophila, Tendipes* for *Chironomus, Itonida* for *Cecidomyia,* etc., has brought into the literature the family names *Fungivoridae, Tendipedidae, Itonididae,* etc.

The fixation by Schrank in 1801 of *antiopa* as type of *Papilio* would remove the *Papilionidae* as a designation for the group of swallow-tail butterflies. When Scudder in 1872 made *monuste* the type of *Ascia* Scopoli he inadvertently laid the foundation for the change of the *Pieridae* to the *Asciidae.* While technically for a long time the Mourning-cloak butterfly has been a Papilio and the cabbage butterfly an Asciid, it will probably be a still longer time before the entomological public will agree that they are.

It is in order to check the changing of family names whenever a type genus is sunk in synonymy that the British National Committee on

Entomological Nomenclature (1928) proposed to change Article 5 of the International code to read: "The name of a family is not to be changed unless it is a homonym, or unless the name of its type genus is transferred to another family or is proved to be a homonym of a genus in another family". While the adoption of this rule would have the anomalous effect of retaining the *Pieridae* with type genus *Ascia, Parnidae* with type genus *Dryops, Agaristidae* with type genus *Phalaenoides, Borboridae* with type genus *Cypsela,* etc. ad lib., it would give to family names a greater stability than is now possible.

Because of the failure of the law of priority to afford parmanence to family names, various writers have advocated the adoption of the continuity principle. Continuity of names, both generic and family, could be attained by two ways, either automatically after a probationary period, or specially by declaration by the International Commission on Nomenclature.

At the second Entomological Congress at Oxford the Rev. George Wheeler (1913) proposed that names in unchallenged use for twenty-five years be irreplaceable. This is in accord with Article 20 of the Botanical Code, which provides for nomina conservanda, those names which have come into general use during the fifty years after publication.

Heikertinger (1916—1923), in a series of papers, has advocated the Kontinuitätsprinzip: names which have been in scientific use for fifty years are not to be changed for nomenclatural reasons. If two or more names are in use the reviewer is to select that which would bring about the least confusion in the literature. If the decision on the valid name is difficult, the earlier name is to be selected, not essentially on account of priority, but because of the likelihood of more extended use during longer service.

As far as I learn this important and far-reaching principle has not been accepted by the Commission on Nomenclature. Its incorporation into the Code would spare the Commission from the task of rendering many future opinions, since its concern would then be only with such names as would be in dispute during the probationary period. The shorter the probationary period the quicker the attainment of a stabilized nomenclature. Handlirsch has suggested thirty years: G. Wheeler sees no advantage in extending it to fifty years.

Regarding the formation of lists of *nomina conservanda* a committee of entomologists at Cornell University, — Bradley (1912), Comstock, Needham, Reed, Riley, Anna Morgan, Herrick, Crosby, Wright, Matheson, and Embody, — in 1912 sent the following request to the Commission on Nomenclature: "To avoid disadvantageous changes in the nomenclature of genera by the strict application of the rules of nomenclature and especially of the principle of priority, the International Commission on Zoological Nomenclature is empowered to prepare such a list of names to be retained. These names are to be by preference those which have come into general use in the fifty years following their publication, especially those generic names upon which long used family names are based and those which have been used in monographs and important works up to the year 1890. With each generic name thus conserved is to be cited a type species to be chosen with a view to retaining the name in its most widely known sense, even if thereby an exception must be made to the other provisions of this code".

In order to fix the names of disputed genera in common use and especially those serving as the basis for family names, Apstein (1915), with the assistance of many specialists, published a list of animals including over a thousand genera of insects, with fixation of date and type species. This list was submitted for ratification to the Commission on Nomenclature, which rendered the opinion that the list was too lengthy for it to act upon in toto. This praiseworthy undertaking had in mind the removal from further molestation of such commonly used names as: *Cimex, Capsus, Gerris, Hydrometra, Phymata, Berytus, Thyreocoris* (Hemiptera); *Helodes, Trogosita, Malachius, Lampyris, Trichopteryx, Cantharis, Scolytus* (Coleoptera); *Acrocera, Borborus, Cecidomyia, Leptis, Mycetophila, Rhyphus, Scatophaga, Scenopinus, Xylophagus* (Diptera); *Proctotrupes, Pompilus* and *Sirex* (Hymenoptera).

Handlirsch, in Schroeder's Handbuch, gives a code of nomenclature, rule VIII. of which states: for every group of animals science recognizes only one valid name, which is regularly the oldest. Only such names may be removed from the action of the law of priority as are universally known and used in many textbooks, or have medicinal, technical or economic use, as well as those on which higher groups are based". In accordance with his view Handlirsch (pp. 91—97) then gives a list of about eight hundred names of families and genera as nomina conservanda to be removed from further dispute.

McAtee (1926) has voiced the main objections to the adoption of nomina conservanda, as follows: "such names will block the development of taxonomy, they will not succeed in preserving definite concepts, they are unfair to early workers, and they will be ignored by taxonomists". In answer, the dictionary may be cited as serving a purpose similar to the proposed list. The dictionary has not blocked the progress of language, though it may be unfair to early workers; it does help to preserve definite concepts, and it is being constantly used.

Summary.

The different conditions set forth on the foregoing pages and the effects they produce may be concisely stated in the following tabulation:

A. Application of the law of priority (no permanent type genus for the family; family concept subject to change).

B. Provisions for establishing family name.

C. Application of priority to family name (selection of family name determines type genus).

1. All family endings to be considered (method of van Duzee, Banks, Oberholser).

2. Only-idae names to be considered (method of Handlirsch).

C.C. Application of priority rule to type genus (selection of type genus determines family name).

3. Oldest genus principle (method of Kirkaldy, McAtee, Karny; the discovery or inclusion of a still older genus would change both the type and the family name).

BB. Provisions for changing family name:

4. International Code (name to be changed whenever type genus is changed).

5. British Entomological Commitee code (name to be changed if homonym, but not if synonym).

AA. Continuity of names irrespective of law of priority (permanence of family concept and of type genus).

6. After probationary period (method of G. Wheeler, Cornell Committee, Heikertinger).

7. Through declaration of nomina conservands by International Commission in case of dispute (method of Apstein, Handlirsch).

8. *Statu quo* policy (method of common sense).

BIBLIOGRAPHY.

1. International Rules of Zoological Nomenclature. Monaco, 1913. Variously reprinted, as Proc. Biol. Soc. Wash, 39, pp. 75—104 (1926).
2. (1915) Apstein, C., and others. — Nomina conservanda; in S. B. Ges. naturf. Fr. Berl. 1915, pp. 152—180; 1916, pp. 161—163.
3. (1912) Banks, N. and Caudell, A. N. — The Entomological Code, Washington, 26 pp. (1912).
4. (1912) Bradley, J. C., and others. — Nomina conservanda; in Science, 36, pp. 10—11.
5. (1914) Cabrera, A. — Code de nomenclature; in Insecta, Rennes. 4, pp. 317—326; pp. 337—340.
6. (1912 Casey, T. L. — Remarks on family names; in Science, 52, p. 491.
7. (1916) Heikertinger, F. — Zur Kritik der strikten Anwendung des Prioritätsprincips in der Nomenklatur; in Wien. Ent. Ztg. 1916, pp. 108—116.
8. (1916) id. — Die Nichteignung des Prioritätsprinzips zur Stabilisierung der Nomenklatur. Das Kontinuitätsprinzip in der Tier- und das Utilitätsprinzip in der Autornennung; in Wien. Ent. Ztg. 37, pp. 129—147.
9. (1924) id. — Was leistet das Kontinuitätsprinzip in der Nomenklatur? in Zool. Anz. 58, pp. 115—131.
10. (1924) id. — Über das Wesen des Kontinuitätsprinzips in der Nomenklatur; in Verh. z. b. Ges. Wien, 73 (1923), pp. 182—186.
11. (1912) Horváth, G. — Sur les noms des familles et des sous-familles du Règne animal; in Verh. 8 Intern. Zool. Kongr. Graz, pp. 851—855.
12. (1923) Karney, H. H. — Über die Anwendung der Nomenklaturregeln; in Ent. Mitt. Berl. 12, pp. 168—198.
13. (1920) Lyon, M. W. — Family and subfamily names in Zoology; in Science 52, p. 291.
14. (1921) Mc Atee, W. L. — The selection of family names in Zoology; in Jl. Wash. Acad. Sci. 11, No. 10, pp. 230—235.
15. (1926) id. — Nomina conservanda from the standpoint of the taxonomist; in Proc. Ent. Soc. Wash. 28, pp. 189—190.
16. (1920) Oberholser, H. C. — The nomenclature of families and subfamilies in Zoology; in Science 52, pp. 142—147.
17. (1912) Stiles, C. W. — The unanimous vote rule in the International Commission on Zoological Nomenclature; in Science 36, pp. 557—558.
18. (1916) van Duzee, E. P. — Priority in family names; in Ann. Ent. Soc. Am. 9, pp. 89—93.
19. (1913) Wheeler, Geo. — Suggestions for securing simplification and permanency in nomenclature; in Tr. Int. Congr. Ent. Oxford, 2, pp. 97—108.
20. (1928) Report of the British National Committee on Entomological Nomenclature; in Proc. Ent. Soc. Lond. 1928.

Discussion.

F. Silvestri: — With respect to the two view-points now existing in the rules governing family names I think that we should adopt a rule for the past and a rule for the future. It cannot be questioned that it would have been much better, if all family names had been derived from the oldest genus, but as this rule was not followed in the past, we must accept any family name based on the name of one of the included genera in order to avoid a useless change. When two or more names have been proposed for the same family, the oldest must be retained, following the law of priority as in the case of genera and species. However, if it is necessary in the future to propose new family names, it must be made compulsory to base them on the oldest valid included generic name.

F. Muir: — Family names should be founded upon a generic name. I am opposed to the oldest genus method, as it necessitates great changes and is not likely to lead to stable results. When erecting a new family, it is advisable to use the oldest name, because it will prevent discussions of the matter. An internationally accepted list of family and subfamily names to be permanent would be of great value.

K. Jordan: — Family names should be stabilised like generic names. A family name need not necessarily be derived from the oldest included generic name, old generic terms frequently being a matter of controversy and uncertainty. A family name need not be changed if the generic term from which it is derived becomes a synonym within the family. A committee for each large Order might draw up a provisional list of *nomina familiarum conservanda*. The same applies to names of other categories higher than genera.

G. F. Ferris: — The establishment of names for every category and of types upon which those names are based up at least to the subclass should be definitely provided for by our nomenclatorial rules.

I would contend that the method followed for selecting the type should be the same in all groups, that is that the selection of a type for a family should follow exactly the same principles as the method used in selecting a generic type.

In general, priority of naming should determine the name which will be selected. The "oldest contained genus" idea as a basis for selecting types impresses me as illogical, unsound and conducive to nomenclatorial changes and confuson. This Congress should definitely take steps toward the clarification of this problem, if necessary regardless of the action of any other body. The establishment of an International Committee to deal with this problem seems a reasonable method of approach. This Committee should concern itself not only with the problem of family names, but with that of the names of all categories.

The Theory of Nomenclature.

Professor Clarence Hamilton Kennedy, Ohio State University, Columbus.

The binomial system of nomenclature in its establishment by Linnaeus appears to have been a discovery and not a well thought out invention. The system of Linnaeus divides readily into two main features. First is his generic and supergeneric classification built up in succeeding orders of size of genera, orders, classes, phyla and kingdoms. This part of the system appears to have been thought out carefully by him by a revaluation and recombination of ideas already developed by John Ray and successors and from the generic classification of ideas worked out in Greek logic. It is an astonishingly sound piece of thinking. Second is his binomial method of designating individual species; but this accidental discovery had no basic theory in its inception.

In the first nine editions of the Systema Naturae no binomial system of nomenclature was used. Each species was given a generic or group name, an idea coming down from Greek logic. This generic name was followed by a short description of from one to three or four lines in Latin. Linnaeus considered the generic name plus the condensed Latin description the name of the species. This obviously was a very lengthy and unwieldy designation.

By the time of the publication of the ninth edition of the Systema Naturae other naturalists were describing new species; so in order to make the ninth edition complete, the descriptions published by these other workers were quoted in this edition quite numerously. However, to condense the work, Linnaeus in quoting these descriptions used merely the generic name followed by the first adjective of the specific description which was usually the most descriptive adjective. This procedure gave a description condensed to a generic name and one specific name or character. Linnaeus at once saw the value of such a condensed description and in the tenth edition set out in special type the generic name and the first descriptive term of the specific description as the binomial name of the species. Thus arose the binomial system of nomenclature. It came about by the chance of clerical compulsion and the usual high cost of printing.

Except for the beginnings of a systematic philosophy of the natural world devised by Aristotle 300 B. C. the objects in nature still remained in the philosophies of man as a heterogeneous hodge-podge. Linnaeus was the first man to give the world a system that worked. When he started work he found the major groups roughly blocked out by Aristotle and more recently by John Ray and the botanist Tournefort. He had access also to the system for the classification

of ideas as worked out by the Greek logicians. By a recombination of these ideas he built the framework of his general classification. In Greek logic individual ideas or conceptions were specific or rated as species. These were organized into groups of similar ideas or conceptions called by the group name genus. Genera were then organized again as groups of similar genera into a genus of a higher order. Thus in the Greek conception of the world of thought this was organized into a pyramid of genera of ever increasing orders of comprehension, each higher genus being composed of a group of genera of the next lower order, each genus of the lower order being a species of the genus of the next higher order. This was an ingenious and flexible system characteristic of the subtilities of the Greek mind.

Linnaeus used this generic system of the Greeks, but in using it made certain changes. First, he applied the system to natural objects for the first time. Second, he gave specific terms to his genera of the higher levels. Linnaeus grouped species into Genera, then grouped genera into a genus of the next higher order which he termed an Order. Orders were grouped into a genus of the next higher order which he termed a Class. Classes were grouped into Phyla and these into Kingdoms, of which he recognized three, Animal, Vegetable and Mineral. This giving of specific terms to the genera of the higher levels in classification crystalized the system into a fixed entity and produced a system within the comprehension of the ordinary worker. It made a system useable by everbody.

Linnaeus had no conception of a group between the genus and the order. The use of the term Family for such a group has arisen since and was first used in botany by De Jussieu in 1789.

Subfamily and tribal names have come into use even more recently. Neither did Linnaeus have much conception of subspecific terms though he used "varietas" to indicate variant forms. Trinomials, quadrinomials and quinquenomials are of more recent introduction.

Thus arose from a composite of Greek logic and clerical necessity the present system of classifying natural objects. Any one using it finds almost at once its wonderful usefulness and almost as soon runs into its defects. It is not a perfect system. Its imperfections appear to lie in some of the basic assumptions on which it is erected. As no product of thought can be more correct than its basic assumptions let us examine these more closely.

The theory of binomial nomenclature rests on several assumptions, the principal of which are the following: —

1. The assumption that all species of plants and animals are distinct, that there are no intergrades.

2. That every namer of new species is familiar with all previous work in his group.

3. That any person able to publish scientifically is competent to write an adequate description.

4. That all emotional factors are eliminated by the system.

First. The assumption that all species of plants and animals are distinct, that there are no intergrades.

Binomial nomenclature was discovered by Linnaeus when the plant and animal kingdoms were believed to be composed of species always distinct, each having been created in the Garden of Eden by an all wise Creator as a separate and distinct creation. The implication in the theory of special creation was that the Creator knew species and made no mistakes by the creation of intergrades, that the only intermediate forms were hybrids. With the shift in biological theory from that of special creation to that of evolution this first and basic assumption was shown to have a large degree of error. Up to the present day no basic change has been made in the code with regard to this assumption of the distinctness of all species. Instead of changing the nature of the code to tune it to an evolutionary conception of species it has been patched up superficially by the use of trinomials, quadrinomials and even quinquenomials.

Just recently we have travelled even farther and have come face to face with the necessity of devising a system for the designation of physiological species. Every student of life histories in entomology, especially in parasitic and phytophagous groups, can recall insects that cannot be differentiated morphologically, but which have distinct host preferences or other distinct and very specific habits. The genus *Tiphia* of wasps parasitic on scarabaeid grubs presents such a problem. The men working on life histories insist that they are dealing with distinct species because of the specificity of habits and hosts, while the systematists who recognize only morphological species insist on laughing at the troubles of the students of life histories. Can binomial nomenclature take another patch on top of previous patches to give us names for such physiological species?

Thus we see that theoretically binomial nomenclature is designed to deal with constants which do not exist in nature, while true biological theory deals only with variables. Because of this basic difference between the assumption of binomial nomenclature and biological fact the one can never be a perfect fit for the other. Binomial nomenclature by the present system will always be a man made approximation which will have to be constantly patched and even then will never be a perfect definition of the variable species as such occur in nature. This means that the present rules of nomenclature can never be defined by or have exact limits placed on them by any basic biological law. An ideal system of nomenclature would have to be exactly tuned to natural law, which means that such an ideal system would be controlled by or have its limits set by natural law. Thus the present system can never be exactly tuned to species as such occur in nature.

It is a dream that eventually biology may reach the plane of exact definition already attained by mathematics. Theoretically it should some day become as exact. However, the problem is one more difficult than the problems of present day mathematics, because of its infinite complexity. The biological expressions or nomenclature of today compare roughly with the expressions used in the early history of mathematics, when only expressions for constants were in use. Early mathematics dealt only with constants, but almost at once in astronomical work faced the problem of the definition of variables. This was eventually solved by

the discovery of the calculus and the more recent development of method. In biology the problem is more difficult. Physiologists are showing us the profound complexity of the living organism, which is a mechanism of so many and such complex variables that we have no present hope of ever expressing it in any very exact formula. Apparently there is in sight no method of designating species which would parallel mathematics in exactness. We will have to continue with our present binomial system and its modifications which attempts to solve the problem by mere approximation. Even this has been such a useful tool in the orderly classification of natural objects that for the present we should continue its use and by discrete patching make it gradually more exact.

The second basic assumption of the code is that every one who names a new species is familiar with all previous work in his group back to and including the tenth edition of the Systema Naturae of Linnaeus. This assumption includes the collateral assumption that he has a correct conception of the natural groups with which he is working. A second collateral assumption in this same general category is that there will be little difference of opinion as to the size of groups. The inability of the code to anticipate and control difficulties arising from these faulty assumptions has filled biological literature with generic and specific synonyms. The fog of generic synonyms was first cleared by Agassiz in his Nomenclator Zoologicus and later by Scudder and Waterhouse, while that of specific synonyms was cleared by a gentleman's agreement as to priority, which was later enforced by the retroactive legislation of the International Congress of Zoology. These assumptions of the ability of the namer of new groups and new species still hold, are still in error, so that in operation the code still piles up synonyms. However, the code as at present administered will eventually clear the situation, if it is allowed to operate without fear or favor.

This situation could be helped by the frequent bringing up to date of the Nomenclator Zoologicus or other lists of generic names as by the publication annually of such a list. It could be even better cleared by the requirement of the registration of new names in a central bureau before publication where such could be checked. Unfortunately funds for such a bureau are wanting.

The third basic assumption of the code is that any person able to publish scientifically is competent to write an adequate description. The error in this assumption is what has made the preservation of types so necessary. Inadequate description is the bane of systematic work. Descriptions have been improved only by bitter experience. Too often the voluminous describer of species, the so-called authority on the group, is the most careless in writing exact descriptions and in placing the species closely by stating its nearest relatives and how it differs from these. A paper a day looks well in a personal bibliography, at least to the outsider and uninitiated, but in systematic work it stacks up troubles for later students.

The differences in the use and interpretation of terms creep into descriptive literature and add to the confusion of careless work. Language is a personal thing and can never be perfectly standardized. Language and its specific units or terms imply constants besides being only approx-

imate. Variables can never be adequately expressed by terms that are constants, but terms that are only approximations can be greatly helped by the use of good ilustrations. This applies very specifically to descriptions in systematic entomology. Now that by study and experience we have come to know what morphological characters in insects are most often specific, such as the genitalia of the male and often of the female, we can frequently express these specific characters much more clearly in a small illustration than in a page of description. The more conscientious workers in systematic entomology now refuse to publish descriptions except when accompanied by adequate illustration. It is astonishing that illustration in the definition of species is not more often used. As far as the writer has observed every systematic worker actually craves from other workers descriptions with good illustrations, yet too often he himself will rush into print with descriptions that lack any illustrations whatever. His excuse usually is that he cannot draw. This is no excuse whatever for publishing less than as good a description as possible. What would happen to a mathematician who would publish surmises because he could not handle mathematics as well as others could? His work would merely be dropped from exact mathematics. Perhaps with more dropping higher requirements could be applied to advantage in the science of describing new species.

The fourth faulty assumption in our present system of binomial nomenclature is that it automatically eliminates all emotional factors. We have already indicated one such emotional factor that has crept into descriptive work in that illustrations of specific characters are so often omitted by otherwise conscientious workers. They have followed the emotionally easy path and have omitted illustrations that would have immensely eased the work of future workers. Science will only reach its greatest exactness and greatest devolopment with the reduction of the emotional factors to a minimum. While making an illustration may increase the emotions of the producer, it will usually reduce the emotional factor in ten or more later workers, so is time well spent scientifically. Illustrations are certainly of direct scientific benefit in increasing accuracy.

The inability of the code to eliminate the emotional is that which brings up just such programs as we are having today. It brings up just such voluminous correspondence as occurred in the recent case of the Tentamen of Huebner. It has even been such a powerful factor that it has added patches to the code in the shape of bylaws that permit the continued use of names of long standing, though they do not have strict priority.

We have seen from a review of the present code that it is strictly a man made structure. It contains, as shown by a study of its basic assumptions, many elements which could be termed non-scientific and which in operation permit the operation of emotional factors to the very great detriment of the output. The basic assumptions indicate at once that the code is not scientific.

The problem the code attempts to solve is however strictly scientific. It is a problem too intricate to solve at present by any known scientific method and so has to be partially solved by approximation. The problem is scientific. The method of solution is very human.

Because the problem is scientific and because it is one of the most far reaching scientific problems facing man, its solution should approximate scientific method as closely as possible. This means the elimination of the emotional. Science has nothing to do with emotions except to steer clear of them in whatever guise they appear.

The law of priority as devised should eliminate the emotions of selfishness and mistakes due to the various emotions that produce indifference and ignorance. Further, science has nothing to do with morality, as morals are merely the emotional customs of society at any particular time and place. Thus the body of scientists are under no moral obligation whatever to the first namer of a species. From the strictly scientific point of view the only question involved concerning priority is, whether it promotes scientific accuracy. It is purely a problem in mathematics. A simple rule, if fully adequate, increases accuracy. The rule of priority rigidly applied involves three factors: 1) the original publication, 2) the synonym, and 3) the correction. When the rule of priority is set aside there is added to this first set of factors a fourth factor which is the ruling of the International Commission. Such rulings obviously make the code less simple and less scientific and more emotional and more human. The argument for such exceptions to the law of priority come from the second factor, the publication of the synonym, which publication may have been very extensive and over a long period of time. The evaluation of this factor discloses in it a time factor which to the writer is the most important factor in the whole problem.

This time factor is the length of time the synonym has been in use as compared to the whole subsequent history of biological science. Too many biologists think of the code usage as being mature today at the age of one hundred and seventy-five years. Instead it is probably merely in its infancy and the literature now full of synonyms crying for recognition will have been entirely superceded by adequate catalogues and check lists a hundred years hence. In that future time only literary experts interested in biological history will care to dig into the literature of today. As time goes on more and more names will be settled finally by the rule of priority. Eventually in any group (except in such groups as are actively evolving) this process of the stabilization of names will have become complete. If some of these names have been excepted from the rule of priority by special rulings of the Commission, such names will always remain sore spots to be reopened by those craving an inviolate uniform rule. Following a uniform rule of priority will eventually clear the situation as the present literature dissapears into the past. Making exceptions will always leave said exceptions for future arguments. We have not removed the emotional from the code by making exceptions in the rule of priority. We should make the code as scientific as possible and so reduce the emotional factors to a minimum. Elimination of the emotional factors produces stability. The code must be stabilized to become most useful.

Discussion.

F. Muir: — Science is under no obligation whatever to the taxonomist who first proposed a name; often the work was so badly done that he conferred no blessing upon science. Priority is a good guide to start

with, but should never be made a fetish. The chief objective should be continuity and convenience. The future of entomology cannot be advanced by changes in past names, but rather by preventing any changes in the future.

The most imperative need of entomological nomenclature today is to prevent changes of names in future, and anything that will have this effect, even to a small extent, should be earnestly considered by entomologists. If we look through any modern taxonomic monograph of a well worked group of animals, it is difficult to maintain that we use a binominal nomenclature. In very few cases has the original combination of genus and species been retained, and once that is broken, it is necessary to quote the original combination to retain continuity; a specific name by itself is useless. This fact is emphasized by the International Commission on Zoological Nomenclature in the resolution presented to the International Zoölogical Congress at Budapest in 1927: — (b) "It is requested that an author who quotes a generic name, or a specific name, shall add at least once the author and year of publication of the quoted name, or a full bibliographic reference". Here they are asking for three factors for identifying the genus and three for the species. If we would act upon these facts, we could at once eliminate one cause of the alteration of specific names. If we recognize the author's name as part of the specific name, then *parvus* Smith would not be preoccupied by *parvus* Jones, if they came together in the same genus. This would in no way relieve any author from the moral obligation of avoiding duplication of a name in the same genus.

F. Silvestri: — The principle of priority must remain unquestioned, because if power be given to some Commission to suspend this law, the Commission might follow today some rules in accordance with the ideas of the present members of the Commission, and tomorrow, when other men are in it, it might apply different directives, and so on. In my opinion there exists here a great danger. But if we accept priority, we may nevertheless ask ourselves: is it worth while to spend a great deal of time on solving some very complicated questions of synonymy of old names, which sometimes might even mean a most inconvenient change of family names? In order to avoid too many changes — which involve a loss of time, and money for printing — I think we should agree on the point of view taken by the International Congress of Zoology at Monaco with regard to names which were in general use until 1900. In any case, it would be very opportune to agree that the nomenclature of the greatest catalogues or the greatest monographs be accepted, at least as regards the names of the more common insects, the names of which should be regarded as unchangeable. Nomenclature is a tool which must be made as perfect as possible; but it must not be looked upon as an end in itself and made a field for interminable controversies, especially when the names of old species are under consideration. As to the acceptance of a name, the examination of the type by a specialist should be sufficient to exclude definitely any question; but if the type is lost and the description is not good enough for determination, I think the following rule should be followed: the said name should be referred to that species which has been collected in the locality indicated by the first describer and has no characters contradictory to those mentioned in the original description. It

is most regrettable that many authors reject names with the remark "not recognizable" and create others in the hope that tomorrow there will be no pretentious auther who will treat their own names in the same way.

We must recommend rules which aim at the simplification and not at the complication of Nomenclature, which is already very complicated in itself on account of the immense number of existing species. We must especially remember that respect is due to other workers, and abstain from creating any names without adequate descriptions. But we know only too well that perfection is not a property of the human being, and we must, therefore, maintain the law of priority; only a few exceptions regarding old names of very common species should be allowed and these names be made unchangeable for the sake of saving time and money, both of which are very much needed for progress.

G. Talbot: — I am of opinion that nomenclature must be guided by principle or endless confusion will result. The principle of priority must be observed for all names which are accompanied by a description or by a figure, unless such description or figure is found to be useless for identification by a specialist. A mere name for a species, which might apply to more than one insect, is obviously of no value. So I would reject the Tentamen of Hübner. To suspend the operation of the law of priority in particular cases is unsound. If someone has perpetrated an error, the error should be corrected as soon as discovered, and any name which does not comform to the principle laid down, must be rejected.

At some future time, priority may become dependent upon the publication of the name in an international catalogue, and also upon its original publication in a place previously agreed upon. That is to say, a list of scientific periodicals should be drawn up in any one of which a name in Entomology may be published. This should be an official list and should not include any book of travel, any newspaper, or any periodical devoted to other branches of Zoology. There would be no bar to a work published separately by an author.

The Problem of Arsenical Residues: Importance of Spray Deposits from the Standpoint of Public Health.

Harry A. Kuhn, Chemical Warfare Service, Edgewood Arsenal, Edgewood, Maryland.

(Abstract.)

Comparative Toxicity of Insecticides.

The minimal lethal dose of a number of insecticides, administered by mouth in warm-blooded animals, was determined. The compounds investigated included arsenious oxide, calcium arsenite, calcium arsenate, lead arsenate, barium fluoride and sodium fluosilicate.

The experiments were carried out using rabbits and dogs, most of the determinations being with dogs. The compounds were administered in capsules into the empty stomach. Vomiting of the capsule by the dogs was prevented by administration of morphine about one hour prior to the capsule. The physiological and pathological effects of the compounds were noted.

The arsenious oxide used was 100% As_2O_3, and 99.8% passed thru a 300 mesh screen. The average size of the particles was 10.5 mu. The minimal lethal dose for rabbits was found to be approximately 20 milligrams per kilogram body weight, and for dogs 85 milligrams per kilogram body weight.

The calcium arsenite consisted of 46.8% calcium arsenite, 6.8% calcium arsenate, and 45.8% arsenious oxide. The minimal lethal dose for dogs was found to be 8 milligrams per kilogram body weight.

The calcium arsenate was found to be 70.5% $Ca_3(AsO_4)_2$ with an excess of calcium oxide and with approximately 0.2% water soluble arsenic, calculated as As_2O_5. The minimal lethal dose for dogs by mouth was found to be 38 milligrams per kilogram body weight, and for rabbits 50 milligrams per kilogram body weight.

The lead arsenate was a commercial grade and on analysis was found to be chiefly $PbHAsO_4$. The minimal lethal dose by mouth for dogs was found to be 500 milligrams per kilogram body weight.

The sodium fluosilicate contained 74.2% Na_2SiF_6. The minimal lethal dose by mouth for rabbits was found to be 138 milligrams per kilogram body weight, and for dogs 150 milligrams per kilogram body weight.

Barium fluoride on analysis was found to be 99.1% BaF_2. The minimal lethal dose by mouth for rabbits was found to be 200 milligrams per kilogram body weight, and for dogs 550 milligrams per kilogram body weight.

All of the arsenical compounds produced gastro-intestinal irritation and the symptoms and pathological findings were those of acute arsenical poisoning. The principal symptoms observed in the case of the fluorides were those of acute irritation with hemorrhages in the stomach mucosa and intestines. The principal organs affected were the liver and kidneys.

The toxicity of calcium arsenite, when given by mouth, is very close to that of arsenious oxide when administered intravenously. The comparative toxicity of sodium fluosilicate and calcium arsenate is of interest due to the increasing use of sodium fluosilicate. The fluoride is about 27% as toxic as calcium arsenate and in addition does not leave a toxic residue in the soil. The effect of sublethal doses of calcium arsenate may be chronic arsenical poisoning. The principal effect of small doses of fluoride will be loss of appetite, disturbance of digestion, and of calcium balance.

Chronic Lead Poisoning.

In order to study the cumulative effect of sublethal doses of lead arsenate, four dogs were given $^1/_{25}$ of the lethal dose by mouth each 48 hours. The first dog died after receiving $^5/_{25}$ of the minimal lethal dose; the second after receiving $^{11}/_{25}$; the third after receiving $^{20}/_{25}$, and the fourth after receiving $^{23}/_{25}$. All of the dogs developed anemia, bloody diarrhea, and after the fourth dose showed salivation and nasal discharge such as usually found in subacute arsenical poisoning.

The drop in the red blood count was about 30%. The principal organs of the animals were analyzed for lead and arsenic. Arsenic was determined by the electrometric Gutzeit, and the lead by the method of Fairall and Aub. The lead to arsenic ratio in the dog dying after 47 days is of particular interest. In the original compound the ratio of arsenic to lead was 1—3.85. At death it was found to be 1—39.5 in the liver; 1—19.1 in the kidneys; 1—8.9 in the leg bones; 1—5.6 in the spleen. It is apparent that the lead was being retained in the body, while the arsenic was being eliminated.

From a study of the results obtained, it was evident that acute deaths from lead arsenate are due essentially to arsenic, while in chronic poisoning the symptoms are due principally to lead poisoning. In investigating the spray residue on fruit sprayed with lead arsenate, both the arsenic and lead should be determined. The small amount of arsenic in a spray residue will probably do less harm than the lead, due to a very slow elimination of the latter.

The Problem of Arsenical Residues: the Situation in different Apple-Growing Areas and Results of Investigations relative to the Production of Apples to meet Market Requirements.

Leroy Childs, Supt. Hood River Branch Experiment Station, Hood River, Oregon.

The arsenical removal problem, which came forcefully to the attention of apple and pear growers during 1926, presented to them one of the greatest difficulties that ever faced a fruit industry. The problem from a commercial standpoint was both national and international in its aspect, as both of these fruits play an important role in foreign and domestic shipments. Difficulties in this respect were not confined to growers in the United States alone, but also involved many producers in Canada, Australia, New Zealand, South Africa, in fact, in all localities, particularly in the more arid regions, where apples and pears are produced for export shipment. In the United States, the arsenical residue situation is of greatest proportion in the North-western States. In these sections apples are grown in irrigated areas where summer rainfall seldom occurs and where the codling moth demands constant and very thorough applications of arsenate of lead to affect control.

In order to gather information relative to the residue situation in the many apple producing states, a short questionaire was sent out to horticultural representatives in these States. A summary of answers to questions asked are found in the accompanying table; the questions were as follows:

1. Do you have a residue problem in your State?
2. What has been the most efficient means of arsenical removal?
3. Where washing has been employed, what percentage of the crop has been reduced below the tolerance of .01? What below .02?
4. What percentage of the crop in your State requires washing?
5. Has washing or wiping proven injurious to fruit?
6. Has washing or wiping of fruit been met with favorable or unfavorable reactions by the buyer?
7. What percentage of your growers are taking kindly to cleaning measures?
8. Are many growers using substitutes for arsenical sprays? If so, what percentage? What are these substitutes?
9. How many sprays employed — with approximate date?

The survey shows the residue problem is most acute in the Western States in the order named: Colorado, Washington, Oregon, Utah, Idaho, California, with practically no difficulties occurring in Montana. In many sections of these States heavy, late spraying has been found necessary in order to control late brood worms. Fear from late worm damage has

caused many growers to use excessive amounts of spray late in the season, often times unnecessarily, with the result that fruit has been found carrying ten or more times the tolerance of arsenous trioxide. In the Nort-central tier of apple producing States including Minnesota, Wisconsin, Michigan, Iowa, Illinois, Indiana and Ohio, the reports from horticultural authorities indicate that producers as a whole have found it necessary to give little consideration to the residue problem except in a few more or less isolated instances. In the States further south, including Kansas, Missouri, Arkansas, Kentucky, some difficulties are being encountered. In areas where the problem is serious, processing for residue removal is being undertaken. For the most part, this has been in the form of wiping. Much of this fruit is consumed within the States where it is grown, with the result it has not been found necessary to reduce the arsenical load to .01.

In parts of the North-eastern States, including Pennsylvania and New Jersey, some localized areas have had some difficulty, though rather limited in extent. In these sections some wiping and washing with the acid treatment is employed. The survey indicates that little trouble is experienced in New York, Connecticut, Vermont (slight) and New Hampshire. In the South-eastern group of apple producing States, including Virginia, West Virginia, and Georgia, the problem is more acute — much fruit is often exported, all of which must be reduced to the .01 tolerance before shipments can be made. In the Shenandoah Valley late arsenical sprays used for the control of the Oriental peach moth are adding to the difficulty.

In this discussion of the subject limited time will not permit the presentation of a complete history of occurrences that have taken place in the study and condemnation of arsenic in food stuffs and as residue on fruits; likewise, a complete resumé of the experimental work associated with this removal problem can not be given.

Briefly, it may be stated that, following an exhaustive study in England by the "Royal Commission on Arsenical Poisoning" from 1901 to 1903, .01 grains arsenic trioxide per pound of food stuff or .01 grains per gallon of liquid was the established tolerance allowed. This standard has been adopted by other countries including the United States, the latter having employed it for many years against imported goods and other food products. As a result of its general usage, .01 grains per pound of food stuffs can be considered a "World tolerance".

To the growers of apples and pears .01 grains of arsenic trioxide per pound of food stuffs had little meaning until the fall of 1925, at which time rumors of arsenical poisoning occurring in Great Britain, occasioned by the eating of American apples, came to their attention. Following these purported poisonings, local health authorities throughout England subjected American apples to critical chemical analyses. In many cases arsenic trioxide per pound of fruit was found to be much in excess of the established tolerance. These findings were given much publicity by the press, many fruit dealers were fined for selling fruit in violation of the law, stocks were confiscated and destroyed, all of which resulted in the demoralizing of the market and the destruction of confidence in trade. Conditions reached such serious proportions that it was feared, an embargo would be placed upon American apples — an act which would have been a

disastrous blow to the industry in view of the fact that exports to a large extent assist in the handling of our surplus production, as well as making up a large percentage of shipments from a number of localities. The problem at that time was extremely complicated. British health authorities found it necessary to recognize the numerous findings of excessive arsenical residue. Following conferences of government and shipping agents and the assurance on the part of the growers that a conscientious attempt would be made to reduce the residue in future shipments, an embargo was avoided. This assurance was made by growers who at that time possessed little or no idea just how this reduction was to be made. During 1926, largely due to the wiping of much export fruit and segregation of fruit known to be below the tolerance, conditions were much improved, but nevertheless some fruit with excessive amounts of arsenate of lead reached foreign markets. During the year 1926 much was learned relative to the removal of arsenic from apples, with the result that grower, shipper and exporter agreed to make no further shipments of fruit to Great Britain carrying more than the tolerance. This agreement has been fulfilled, and shipments of 1927 and 1928 have been for the most part above question. The satisfactory solution of this difficult situation is a splendid example of international diplomacy, involving not only State Departments of two nations, but confidences guaranteed by shippers, dealers and growers who made promises that involved the revolution of their packing and handling methods.

The rapid progress made in solving the problems associated with the actual residue difficulty itself speaks well for the adaptability of our various agricultural and horticultural agencies in facing an emergency. The problem was vigorously attacked by representatives of the Bureaus of Entomology, Plant Industry and Chemistry of the United States Department of Agriculture, as well as by Entomologists, Plant Pathologists, and Chemists in the various State Experiment Stations. The part manufacturers of cleaning machinery have played is no small item in the progress that has been made.

Within the space of two years the more important difficulties have been determined and the packing and handling of a crop valued between 50 and 75 million dollars revolutionized. These matters not only included an understanding of the actual removal of residues of arsenic, but lead as well the physical and physiological effect on treated fruit; influence on keeping quality not only from the storage and dessert standpoint, but possible decay produced by added handling and treatment. The writer will attempt briefly to summarize the more important findings of investigators working on the many phases of this problem.

Our domestic difficulties with arsenic on fruit have never reached the proportions that occurred in England. Enforcement regulations were first called to the attention of Federal pure food authorities by seizures in Boston of fruit from the Pacific Coast during the years 1919 and 1920, by municipal officials of that city. It was suggested at that time that the use of arsenical sprays be so modified that the residue on shipped fruit be reduced. It was not, however, until the British difficulties arose that definite steps were taken on the part of our Federal government to enforce regulations already prevailing for other food commodities. Enforcement

of the regulations was authorized for the 1926 crop. Many factors occuring at this time made such action expedient. In the first place, it was believed such action would assist the industry in meeting the export tolerance; second, it was felt that wide spread publicity on the part of the press, as had occurred in Great Britain, would seriously curtail apple consumption, with accompanying disaster to this important industry; third, authorities in charge of pure food regulations felt a moral obligation to enforce the law as it was doing in the case of other commodities, because of adverse publicity rapidly getting out of bounds at the time.

At the outset it was found that the residue problem, in its most serious form, was confined to the apple growing states of the North-west and to a somewhat less extent in California and other States. This area (the Northwest) produces approximately fifty thousand carloads of apples and pears, a large percentage of which (at least 75 %) carried at that time more than .01 grains of arsenic per pound at harvest time.

The spraying schedule throughout this area is quite variable, applications include a calyx and one or two cover sprays of arsenate of lead to a maximum of seven or eight cover sprays (limited sections of Washington, Oregon and Colorado). Strengths used range from 2 to 4 pounds to 100 gallons of spray. Usually the districts employing the greatest number of applications use the heavier dosages, thereby increasing their residue problem. In order to assist in lowering the amount of residue, all possible methods were employed during 1926 and subsequently to reduce the residue to the minimum at harvest time. Particular attention was given to seasonal behavior of the codling moth and sprays were recommended at critical times in order that growers might reduce the applications to the smallest number. It was, however, understood these applications would not be reduced to a point where crop losses would be extensive. Special attention was given to first brood worm control in many parts. In general this has been found to be of little value in meeting the .01 tolerance throughout the West. Banding and methods of orchard sanitation, such as scraping of trees and renovation of infested packing houses, have been employed quite generally. The Entomologist has been giving much attention to substitutes for arsenate of lead in codling moth control during the past few years. This subject will be discussed by Mr. Newcomer at this conference. It can be said no effective substitute is in sight for the arsenical applications at this time.

The residue problem became a reality to Western fruit growers when the Medford, Oregon, growers started shipment of pears in the fall of 1926. At that time there was available very little information on arsenic removal.

Following the Boston difficulty in 1919, R. H. Robinson, Chemist of the Oregon Station, made some tests relative to arsenic removal. From correspondence the following is quoted: "The following summer (1920) I selected samples that had been sprayed with two and more cover sprays which, in referring back to my results, showed far more than .01 grains arsenous oxide per pound of fruit. As a consequence and in preparation of a possible emergency, I made enough analyses of wiped, stored fruit and carried on preliminary tests, using solvents for removing the residue. The early tests made were really not considered seriously, owing first to the

fact that the possibilities of treating fruit in a strong mineral acid or alkali would probably be injurious to the fruit, furthermore, the waxy fruit that I treated showed above .01 after treatment in 1% acid and sodium hydroxide. However, I treated a lot of fruit in nitric acid and W. S. Brown put the fruit in storage to note the possible injury. None whatsoever was observed, but owing to the fact that the Newtown apples, which were used, were waxy, we could not conclude that the acid treatment would not be injurious."

As a result of these preliminary observations by Robinson, the Experiment Station authorities looked upon the packing and residue problem with some misgivings. Growers up to this time had anticipated that the difficulty could be met by wiping, as this practice had often been employed in many sections for the removal of dust and visible spray material for the purpose of improving the appearance of the commodity. The packing season had hardly opened in the Medford district when it was observed that the tolerance of .01 could not anywhere near be reached by hand wiping, machine wiping, wet cloth wiping, and numerous other methods. In other words, it was found there was a vast difference between visibly clean and chemically clean fruit. Preparation had been made quite generally throughout the North-west to meet the residue problem by the wiping of fruit, hundreds of wiping machines had been installed for the purpose of meeting the tolerance. This was soon found to be impossible in other districts. Conferences with Federal authorities were held and it was agreed that modification of existing orders and tolerance was necessary in order to avoid ruination of the apple and pear industry. For 1926 fruit was not consficated or destroyed where an honest attempt was made to reduce the arsenical load.

Following the discoveries at Medford, Oregon, that fruit could not be satisfactorily wiped, Robinson, Station Chemist, and Hartman, Station Pomologist, were detailed to investigate control measures. The results of their findings are now available. Practically every possible solvent of arsenate of lead was tested. Whenever any substance of promise was found, these were tested at different dilutions and fruit placed in storage for further observation. As a result of their work the hydrochloric acid treatment was developed as the most promising. In mid-season growers in the Medford district switched from wiping to washing. Methods were crude and for the most part home-made vats were used. Fully 50% of the crop was treated. Chemists were employed to watch the acid concentration, neutralizing vats and make chemical analyses of the effectiveness of the process. Practically no damage resulted from the treatment. Progress was such that growers in this district looked upon the future with much more confidence.

I have cited this Medford situation to give you an idea of the rapidity with which the industry had to accept new findings and adapt itself to new methods of handling fruit. Considered in terms of tens of thousands of carloads, it has been a stupendous undertaking. Hundreds of thousands of dollars worth of wiping equipment purchased were found to be worthless. Extensive investigations by Hartman and Robinson of the Oregon Station, Fisher and Diehl of the Bureau of Plant Industry, Heald and others of the Washington Experiment Station, have demon-

strated the futility of wiping apples and pears for arsenical removal where the residue is much above .01 at harvest time. The results of these investigations have been remarkably consistent along this line in that they have found wiping either by hand or by machine reduces the arsenical load approximately one-third of the original amount. On fruit close to the tolerance satisfactory removal can be obtained, but this condition prevails on a very small percentage of the fruit grown in the North-west.

Following the practical demonstration of washing (mostly pears) in the Medford district in 1926 and the general failure to meet the tolerance during that season throughout the apple sections of the North-west, the only alternative was to consider the washing of the apple crop for the year 1927. Growers approached the packing season with much apprehension in many districts. It was utterly impossible to supply the industry with sufficient washing equipment to handle the crop, though five or six manufacturers of growers' supplies were in the field with machines, none of which had been tested in more than a very limited way and all of which were far from being standardized. With the 1926 expense of buying wiping machines — which were found to be useless — and with the 1927 season approaching as an experimental washing season, prospects for profits appeared far from bright. Regardless of the fact that washing tests were limited and machinery untested, growers equipped themselves with washers so far as manufacturers could supply them.

In the Hood River and Medford districts of Oregon sufficient machinery was installed that all fruit in these sections demanding attention could be washed. In the larger apple districts of Yakima and Wenatchee, it was physically impossible to install adequate washing equipment to handle the crop. Approximately 12,000 carloads of fruit were washed in the North-west during 1927 — a tremendous undertaking when considering the fact that there was almost an entire lack of previous experience. It is the grower's greatest expression of his willingness to meet the law's requirements and the demands of the consumer. In this extensive washing experience, difficulties were naturally encountered. It is interesting to note that, relatively speaking, little serious damage to the fruit occurred. One machine of the deep submersion type caused extensive damage to certain varieties due to calyx and core penetration of the solution. This difficulty was detected early in the packing season and its use as submergers discontinued. Records are not available which show the percentage of washed fruit reduced to .01 or less. Undoubtedly an appreciable percentage failed to do so. A summary of total analyzes made in the Wenatchee district of washed apples for all varieties and all methods show that 66.0% reached .01 or less; 18% ranged between .011 and .015; 10% between .016 and .02 with 6% over .02. In the Hood River district 89% of all analyses of washed fruit reached .01 or under.

As the season progressed, more difficulty was encountered in the removal of arsenic due largely to wax formation. In general, practical experience gained during the year will be of material assistance in avoiding difficulties that occurred last season, even though at least twice as much fruit will be processed in 1928.

This extensive experience was of such a character during 1927 that growers are approaching the packing season of 1928 with much more

confidence than has been the case since 1925. Vast improvements have been made, not only in washing machines themselves, but methods of treatment are now sufficiently well understood that the problem does not offer serious hazards to the industry.

With the development of the washing process and its rather wide acceptance by growers, apprehension was voiced by a limited number of fruit buyers and in a few places by manufacturers of dry equipment, who were opposed to the development of washing methods. This sentiment was publicly expressed by some shippers and the Eastern trade circularized, warning them of possible dangers that might be encountered in handling washed apples. Because of this unfavorable publicity, dealers in many markets were looking for trouble, with a result during the early part of the season (1927) all condition difficulties encountered with fruit were charged to the washing process. Internal breakdown was quite prevalent in some sections last year, particularly on the Jonathan and Rome varieties. Investigation of complaints usually revealed the fact that buyers were not sure whether the fruit complained of was washed or not, and further, the greatest amount of breakdown was observed in shipments from a district where no washing was done on account of little or no residue problem. As has already been pointed out, difficulties were encountered with the submerger type of machine. Most of the fruit so handled was repacked before it was shipped and the matter corrected before the fruit reached the market. As the season advanced, confidence was established to a point where many dealers preferred washed fruit. There are a few growers in practically all districts who maintain residue removal is unjust, and enforcement of the pure food regulations unwarranted. The majority are now convinced the issue can best be met by washing.

Mr. D. F. Fisher, in correspondence, expresses the general feeling at this time as it occurs in Wenatchee, Wash., the largest apple shipping district in the country: "The opposition to washing seems to be very much abated at the present time, because I think, on the whole, the last season wound up very well indeed, and, after all, it is the return that counts. The industry here is now convinced that washing is not only practical but profitable as well. Many packers have proved that they can wash cheaper than they can wipe — and since they now know the hazards (which was not the case last year) they are entering this season with greater confidence. I believe their greatest concern right now is how much of the crop they can actually get below the .01 tolerance. Central packing plants and growers who washed last year will without exception, so far as I know, continue to wash this year, and I know of many others who will wash for the first time. I estimate that close to 10,000 cars of apples will be washed in this district this year." This quite accurately expresses the attitude of the majority of producers throughout the North-west, though some rather bitter opposition prevails in a few rather limited sections.

Costs of commercial washing can not be properly evaluated at the present time due to the fact both equipment and processes have been passing through the experimental stage. Cleaning measures have cost the growers of the North-west large sums of money due to the fact much experimentation has been necessary in the commercial preparation of fruit for market. Much expensive equipment has become obsolete in a very

short time with the result costs charged to any one crop would be excessive. 1928 costs will become more stabilized and it is anticipated this cost will prove to be very reasonable. Numerous packing agencies during 1927 washed apples at the rate of 5 cents per box. The Apple Growers Association of Hood River has supplied the writer with some actual cost figures obtained in their operations in 1927. Fourteen washing machines averaged 18.900 packed boxes for the two months packing season. Average acid and formaldehyde cost was $84.70 per machine. Average power and extra labor charge $135.00: depreciation at 25%—$375.000, or a total operating cost of $594.70 per machine. The total box cost is slightly more than 3 cents per box. Packers point out there is a concealed cost which can not be accurately estimated. This is due to delays occurring in the washing process, a factor which stops action all along the grading machine, naturally adding to the total packing charge.

Many packers are convinced that eventually washing will be found not to increase the cost of handling due to the fact that thorough cleaning of the apples increases the efficiency of sorters to such an extent washing costs will be largely offset. It is also pointed out that appearance of the pack, as a result of washing, is greatly improved, a condition which doubtless will be recognized by the trade.

Following the preliminary work carried on in Medford, Oregon, during 1926 by the Oregon Station, at which time hydrochloric acid treatment was found to be the most practical of a large number of solvents tested, more extensive tests were carried into execution in practically all of the important producing centers of the North-west, that a satisfactory procedure might be adapted to varying conditions and varieties of fruits produced in the different districts. These studies involved the testing of different methods of application of the solvents, including deep submersion, shallow submersion, floatation, jet washers of various types under pressure, and flood washes; relation to and influence of these treatments on the appearance, storage, and keeping quality of the fruit, study of acid concentrations and temperatures in relation to wax development as the packing season advanced. Alkaline solvents in general have not proven as effective as acid for several reasons. Browning about lenticels and upon russet varieties of pears often follows treatment with bases. Rinsing is accomplished with difficulty with these materials, satisfactory removal of Bordeaux sprays and mixtures carrying lime is not accomplished, natural wax removal occurs which has a tendency to increase weight losses after packing. On the other hand, the use of alkaline materials would solve one of the most important problems in washing machine construction. The prevention of acid corrosion has been one of the manufacturer's greatest difficulties. All metal parts must be kept covered with acid proof paint. This feature requires continual careful attention on the part of the operator in order to prevent excessive deterioration. Monell metal is employed in the construction of machines at points where paint can not be used. This material is quite expensive. Further observations, however, are being made with substitutes for the hydrochloric treatment, including proprietary materials now on the market.

Generally speaking, results obtained by investigators, carried on indepedently in these widely separated sections, are for the most part in

accord. When properly used the hydrochloric acid treatment has been found effective and non-injurious to fruit. There are, however, a number of important factors which must be taken into consideration if trouble is to be avoided. Fisher and Diehl in Washington and Hartman in Oregon have found that submersion of varieties possessing deep calyx cavities — varieties often times possessing open tubes leading into the core cavity — can not be washed in this manner without acid penetration. Treatment of this type has usually been followed by serious discoloration or decay. With apples of this sort a submersion of five inches has caused difficulty; as a result of this damaging effect submersion methods are being discouraged. Commercial washers of the jet type as well as with the flood wash have been found effective, though occasionally there occurs slight acid penetration in apples with open calyxes and cores. Acid injury, which appears as a brownish scald, can be entirely avoided by the use of adequate, clean, rinse water. A neutralizing bath has been found non-essential. Hydrochloric acid, a volatile, non-oxidizing compound entirely disappears from washed fruit. Fruit so treated is therefore safe for human consumption.

Concentrations of acid needed for satisfactory removal vary: (1) with varieties of apples and pears, (2) with the amount of dust and dirt present incorporated in the spray, and (3) with the date of treatment and the development of natural wax on the fruit. Generally speaking, fruit washed immediately following harvest can be reduced within 30 seconds to .01 at a concentration of 1% commercial acid (.33% actual acid) with jet types and flood wash machines; mechanical action with the acid increases its efficiency due to the fact that unreacted acid is constantly brought in contact with both arsenic and lead. As the season advanced, it has been found advantageous to increase the acid concentration and length of exposure. This has been used with safety at strengths as high as six gallons to the hundred. Efficiency, however, has not increased proportionally with acid increase. Fisher and Diehl, as well as Hartman and Robinson, have found that heating of the solution materially increases efficiency of the acid. Tests by Fisher and Diehl point out no damage to fruit occurs at temperatures as high as 120° F. For difficult cleaning they recommended a temperature of 90 to 100° F with an acid concentration of not more than 3 gallons to 100 of water. Heating of the solution has been accomplished by use of electric heaters and steam coils. Robinson has found that dust accumulations on heavily sprayed fruit in Oregon, where clean cultivation is practised, greatly retards acid action and cleaning. The use of lime in the lead sprays materially assists in this removal. At the present time the writer has under observation a large series of spraying tests, employing lime at different strengths and at different times to determine its value in solving this cleaning problem as well as the influence on the control of the codling moth.

Incident to the washing investigations Fisher has definitely determined the cause of so called "calyx rot", which, during some seasons, has caused serious losses in the apple districts of the North-west — particularly during harvest season with occurrence of excessive rainfall. Soluble arsenic has been found the cause for the blackening of the calyx tissue.

This was first encountered in fruit washed in acid and for a time was called "acid burn". Extensive tests have proven this to be due to soluble arsenic, the product of reaction in the acid bath. This injury is typical of that often found in the orchard at picking time. For control of this difficulty in the washing process frequent acid change and thorough rinsing are stressed. Lime water should be added to the rinsing bath, made up in a strength of two pounds CaO to 50 gallons of water. In the orchard gradual change of arsenate to the soluble form is responsible for the damage. In Oregon orchards, where Bordeaux mixture has been used in the late sprays, little injury of this character has been observed. The writer is recommending lime or Bordeaux mixture in the late codling moth sprays for the purpose of controlling this difficulty as well as assisting in the removal of the spray due to more favorable acid reaction at the time of washing.

Acid treatment has been found non-injurious to the dessert and keeping quality of fruit. Both Heald and Hartman have shown that washing has been accomplished with little or no loss of weight of fruit after being placed in various types of storage. Some weight losses accompanied wiping and alkaline treatments.

A matter of greatest concern to both investigators and growers, during the first year of washing, was the matter of drying fruit, particularly with reference to possible consequences following wet packing. Adequate drying has proven to be one of the most difficult factors involved in the cleaning process. Brushes, rag wipers, towel drapes and direct air blasts have been employed with varying success. Air blasts of high velocity, striking the fruit at various angles, have proven most effective, but at best these have not completely dryed the fruit, particularly late in the season. Methods involving wiping in various ways are not desirable in that possibility of mechanical injury is increased as well as a further dissemination of spores of rot producing fungi is made possible. Apprehensions prevailing insofar as the packing of moist fruit was concerned were not well founded. Eliminating the calyx difficulty, due to soluble arsenic, various investigators have found little difference in rot development with fruit carrying moisture in varying degree than in dry, untreated packs. Normal behavior of fruit, so treated, has occurred in storage. Less rot, however, has developed in the case of fruit placed immediately into cold storage than in common storage lots. This has been found true in the case of both treated and untreated fruit.

It is a well known fact the more fruit is subjected to handling during the packing process the greater are the chances of mechanical injuries and subsequent losses due to the development of fruit rot organisms, of which there are several. This phase of the residue removal problem was also a matter of grave concern, not only to growers and shippers, but to many investigators who have been closely associated with the industry. During this period of packing revolution many important findings have been made by investigators relative to the handlings of the storage decay problem. Among the more important decay organisms are the blue, gray and black molds, of which there are several types of each found quite generally throughout the districts of the North-west. More limited in distribution, but of extreme importance where found, are the rots produced by apple tree anthracnose and perennial canker. Heald, studying

the blue molds, for the most part, has found that apples from the orchard often times carry from 5,000 to 100,000 spores, many of which were found to be of harmless types. A study of the spore accumulation in acid and rinse tanks was made; in all cases blue mould was found present. In a normal day's run spore increase per cubic centimeter in acid tanks has been observed to be from 1,200 to 12,500. Accumulations of the same character were noted in rinsing tanks. It has been definitely shown by keeping down the spore population in the washing solutions, percentage of decay can be materially reduced. Weak dilutions of hydrochloric acid have not affected viability of spores. Fisher, Zeller, as well as Heald, have found that formaldehyde will destroy these spores. One quart to 100 gallons of solution in the tanks destroys all spores when allowed to stand overnight. At a strength of 1 gallon to 100 gallons an exposure of two hours destroys practically all spores. Formaldehyde was used quite extensively in the Hood River district during the 1927 season. No injury resulted from its use where the rinse water was kept free from this chemical. Accumulations, however, in the rinse water caused spotting of the fruit. The use of formaldehyde in the acid assures a sterile tank with the start of each morning's run, but owing to the fact introduction of apple carrying large numbers of spores — which require hours for their destruction — definitely limits the effectiveness of such usage. In so far as the blue molds are concerned, infection does not occur on apples free from injury, regardless of the treatment. Careful handling and sorting is therefore highly essential. Frequent acid change and use of large amounts of fresh rinse water is believed to be the most practical method of meeting the decay solution by packers and investigators as well. Where possible, a spray of fresh water should be used as the fruit passes out of the rinse into the drier. Mechanical action of water has been found greatly to reduce spore population on fruit. Daily change of the wash is to be extensively employed in the Hood River district, during the 1928 packing season with little or no use of a disinfectant. Rotted, spore-covered, apples will be vigorously watched and kept from the washing machines.

Little of a definite nature is known at the present time relative to the relation of the washing treatment to further the spread of anthracnose and perennial canker — a tree canker infection from which spores are disseminated on fruit as a result of early rains, just before or during harvest. Experimental work thus far carried on indicates washing alone may be beneficial due to mechanical removal of spores. It can at least be stated, where well regulated washing treatments have been employed, no increases in decay from these sources have occurred in the case of packed fruit.

The entomologist's interests, insofar as the elimination of the residue problem is concerned, have been more along the line of the study of arsenical substitutes; the modification of control measures through more thorough attention to first brood moth elimination; and biological control. The writer, along with many others, has been testing a large number of combinations in an attempt to bring about changes which might prove of value to the fruit industry in the use of arsenical sprays. Arsenicals applied in the form of dust offers some promise in sections where the

codling moth is controlled with relative ease and where conditions are correct for effective application of these materials. The tolerance of .01 has usually been reached by the wiping process on dusted apples. This is probably due to the fact no excessive accumulations of the materials occur at calyx and stem end, a condition commonly found on sprayed fruit. In general, dusting has not proven practical in sections of the North-west where it has been tested.

A survey of the findings of entomologists indicate no immediate substitute for arsenical sprays will be found. More than five hundred species of insects have been recorded feeding upon the apple, a large number of these are controlled by arsenical sprays. A half century of careful investigation has brought to us the control measures we now know. Even though other means of handling the codling moth were found, it does not necessarily follow that the grower, at some time or under certain conditions, would not find himself facing a residue problem due to the fact that a late spray was found to be necessary in order to save a crop from the attack by any one of a number of insects. Until our whole list of insects are re-studied and new methods of control determined, arsenical sprays will have to be employed.

For the present, at least, the shortest and most effective way to meet this problem appears to be arsenical removal. The great strides made along this line point to an early solution of the difficulty as it occurs on apples and pears, which, considered from the standpoint of public health, improvement in the appearance and cleanliness of the commodity, is a very definite progressive step on the part of the industry. A step taken with great difficulty and often times with hardships to the individual during the transitional period, which, it is now believed, will eventually prove of much value to the individual as well as the industry as a whole.

Due to a more scrutinizing consuming public, undesirable spray residues, including arsenic, lead and other materials used for spraying purposes, were bound to come up for discussion, not only by the public itself, but by those in charge of enforcing existing, rather definite pure food regulations. Entomologists will find it necessary to pay more attention, as time goes on, to matters of residue in their investigational work.

Literature.

1. R. H. Robinson and H. Hartman, Dipping Process and its effect on the Keeping Quality of Fruits; Circular of Information 11, Ore. Exp. Station, September, 1926.

2. F. D. Heald, J. Neller, N. L. Overly, Progress Report Spray Residue Committee; Report 5, Wash. Exp. Sta. Nov. 18, 1926.

3. Removal of Arsenate of Lead from Sprayed Fruit; Colorado Experiment Station, Press Bull. No. 63, December, 1926.

4. R. H. Robinson and Henry Hartman, Residue from Apples and Pears; Oregon Exp. Station Bull. 226, Feb. 1927.

5. Albert Hartzel and Frank Wilcox, The Arsenic Content of Sprayed Apples; in Jr. Econ. Ent. Vol. 20, No. 1, Feb., 1927.

6. F. D. Heald, J. R. Neller, F. L. Overly and H. J. Dana, Arsenical Spray Residue and its removal from Apples; Washington Experiment Station, Bull. 213, March, 1927.

7. D. F. Fisher and E. L. Reeves, Quality of Apples and Pears; Proc. Wash. State Hort. Assn., 1927.

8. H. C. Diehl and L. A. Fletcher, Fruit cleaning Methods and their Efficiency; 19th Annual Report, Oregon State Hort. Soc. Dec., 1927.

9. D. F. Fisher, Storage rots and their Control; ibid.

10. D. F. Fisher and E. L. Reeves, Influences of Cleaning Treatments on Storage Diseases of Apples and Pears; Proc. 33rd Annual Meeting Idaho State Hort. Soc. Feb. 1, 1928.

11. F. W. Pettey, Removal of Spray Residue from Pears and Apples; The S. A. Fruit Grower & Smallholder, March, 1928, Vol. XV.

12. Actual Results in Spray Residue Removal; Better Fruit, Vol. XXII, No. 8, Feb., 1928.

13. Leroy Childs, Complete Spray Calender for 1928; ibid., Feb., 1928.

14. Henry Hartman, R. H. Robinson and S. M. Zeller, The Removal of Spray Residue from Apples and Pears; Oregon Exp. Sta. Bull. 234, June, 1928.

Forum on Problems of Taxonomy: Types.

Dr. W. J. Holland, Pittsburgh, Penna.

A name is a word by which a thing is known. According to the ancient Hebrew scriptures there was assigned to Adam the task of naming the things which were about him. We read: "Whatsoever the man called every living creature that was the name thereof." But Adam does not appear to have completed the undertaking assigned to him. After his decease there occurred that little mishap at the Tower of Babel, and even the partial work which Adam had accomplished was undone. There arose a great confusion in names, as we all know to our sorrow.

Linnaeus, *nomen venerabile!*, undertook the work of classifying all things "in the heavens above, the earth beneath, and in the waters under the earth." He indeed had had predecessors in past ages, but the matter was still not much further along, if even as far along, as when Adam went to his grave. Linnaeus invented a system of nomenclature in order to the classification of things, and thus in order to prepare the way for the intelligent study of all matters pertaining to the things themselves. A correct and fixed nomenclature is an imperative antecedent to all truly scientific investigation and discussion.

Linnaeus was for his time a very learned gentleman. However, he was not omniscient. He was a much better botanist than zoologist. He knew a great deal more about the plants of Sweden than he did, for instance, about the lepidoptera of North America. His method of classifying plants had its day, but has in later years been replaced by what is known as "The Natural System", invented by his friend and fellow-student, De Jussieu, enlarged and amplified by De Candolle and a host of others. His system of classification, so far as it relates to the animal kingdom, pointed the way for his successors, but, like his system for the classification of plants, it too has been abundantly modified as the result of the labors of a host of those who have followed him. As an entomologist, and more specifically as a lepidopterist, I may observe that his classification of all the lepidoptera of the world in three categories, or genera, proved not only unsatisfactory to himself, but to his followers. It quickly became necessary for those who came after him to modify his system by erecting more genera and regrouping not only his genera but those of other early writers under dominant categories which he and they had not employed. Nevertheless his work as a path-finder has always been most highly respected and in one matter has remained enduring. I refer to the specific names which he applied to plants and animals. These specific names have priority and are universally accepted, whenever it is possible to determine what the being

was to which he applied a specific name. This, as we know, is not always easy.

Linnaeus and his cotemporaries knew nothing about "types." Their immediate successors likewise ignored this comparatively modern term. As a student of mammals I venture to say that it is impossible now to find even a trace of the type of the creature which in 1754 Linnaeus named *Elephas indicus,* and which in the "Systema Naturae" he subsequently in 1758 designated as *Elephas maximus.* He cites illustrations given by Seba and Aldrovandi. He perhaps had once seen the brute in a zoölogical garden, or, if there were in his day prototypes of Barnum and Bailey, he may have seen one in a "show." But, though the actual type of *Elephas indicus* L. cannot be found in any museum, the creature carries today the generic and specific names applied to it by "The Father of Modern Natural History." Mammalogists are not drawn into lengthy nomenclatorial disputes because the "type" of *Elephas indicus* is non-existent. So also it is with the genus *Homo,* to the single species of which recognized by Linnaeus he gave what has always seemed the highly inappropriate specific name *sapiens.* It may be distressing to mammalogists to be forced with Diogenes of old to confess their inability to find a specimen to which this specific name is strictly applicable. Furthermore, we are here confronted to a most remarkable degree by the phenomenon of "individual variation." When you come to study the subject closely, whether you are the Chancellor of a University, as I have been, or the Warden of a Penitentiary, as I have not been, the "type" of *Homo sapiens* L., like that of *Elephas indicus,* apparently has been hopelessly "lost". But why worry?

The elder naturalists in the eighteenth and the earlier years of the nineteenth centuries knew nothing of "types". I have examined the literature emanating from their pens and I nowhere find the words type, cotype, allotype, paratype, topotype, holotype, lectotype, genotype, etc., etc. We have been informed by Dr. Walther Horn that there are in existence one hundred and nineteen words compounded with the word *type,* which in quite recent years have found a place in zoölogical literature. The nearest approach to the word "type" which occurred, when those gracious and charming old gentlemen corresponded and made exchanges with each other, was when they sent a specimen to a brother naturalist and wrote on the label the words "specimen typicum," which meant that that particular specimen corresponded with their concept of what the species really was.

The fathers of botany and zoölogy did not describe individual plants or animals, but they described species, or what they took to be species. The definition of a species which they had in their minds was that of a certain vegetable or animal form which "bred true" in nature.

It was not until a little before the middle of the nineteenth century that investigators and describers of species began to attach to their labels the word type. Among lepidopterists Boisduval was one of the first to do this. I have in my possession a number of specimens the labels of which in Boisduval's handwriting carry the word "type" after the specific name. The practice became infectious. An author having a number of specimens before him, all of which he believed to belong to the species which he was describing, affixed the word type to the entire suite of

specimens. Then a new departure was made. A conscientious describer, recognising the range of individual variation in the specimens before him, and, either lacking the necessary gray matter to express in generalized terms the common factors belonging to the whole series, or else being too lazy to do so, chose a single individual, which appeared to him to most nearly represent the common features of the individuals before him, and described this one specimen, affixing the word t y p e to its label. He then affixed the word "cotype" to the labels carried by the rest of the specimens which were under his eye.

Against the use of the word "cotype" my friend, the late Lord W a l s i n g h a m , protested. W a l s i n g h a m declared that the word is mongrel, compounded of the Latin preposition *con* and the Greek noun *typos*. His soul was stirred within him and from the standpoint of a classicist he called attention to the vulgarity of such a term. He proposed the substitution of the word "paratype", which did not grate upon his nerves. He was speedily followed by others, who with grace accepted his Lordship's admonitions as to the use of language. He also invented and defined a number of the other words compounded of the Greek word *type* with significant prefixes, derived from the old Greek quarry; and these have come into more or less general use.

N o w w h a t i s a t y p e? Today most zoölogists would reply: "The specimen upon which an author based his original description of the species." But, in the light of what I have already said, this definition, while indeed conforming to most recent practice, is hardly broad enough. Harking back to L i n n a e u s , in a multitude of cases he did not have before him a specimen of the thing to which he gave a specific name. His brief descriptions are based upon illustrations contained in the writings of older authors, descriptions given by them, or specimens which he had noted as contained in cabinets which he had inspected. Take the well known instance of our Monarch butterfly. He cites unter the name *Papilio plexippus* a specimen contained in the collection of P e t i v e r, the London apothecary, whom he had visited. He cites R a y 's "Historia Insectorum." He cites the figure given by Sir H a n s S l o a n e in his famous folio illustrating the Natural History of Jamaica. He cites the plate given by C a t e s b y in his "Natural History of the Carolinas," and then follows with a line of description comparing the specimen with the following species of his list, which happens to be *P. chrysippus.* Although in this original description of *plexippus* he says: „Habitat in America septentrionali", he later, in 1764, speaks of the insect, as it was represented in the Cabinet of the Queen, as from China, and C l e r c k , his pupil, figures the Chinese insect under the name *P. plexippus,* A careful study of the whole subject shows that the insects referred to in the "Systema Naturae" include together with the Monarch, which is correctly figured by C a t e s b y , *Danais berenice,* evidently referred to by R a y and figured by S l o a n e , belonging to the variety later named by B a t e s as *jamaicensis;* P e t i v e r's specimen, which is the well known *Basilarchia disippe,* which mimicks the Monarch, and, if we follow Linnaeus's description, the Danaid of the orient, which by many others has been called D. g e n u t i a. This is a fine mess! Little short of the ingenuity of a Champollion can disentangle the perplexities in which we are involved. I think a final

solution has been reached by our beloved colleague, Dr. Aurivillius, of Stockholm, who unfortunately has just passed away, loaded with years and with honors. Aurivillius has declared that we must accept as the type of *P. plexippus* none of the insects referred to by Linnaeus himself in the Systema Naturae, but the Chinese butterfly, to which he at a later date applied the specific name *plexippus*, and which was figured under that name by Clerck.*)

But, to come back to the question "What is a type?" The species cited by Linnaeus in his "Systema Naturae" in many cases apparently were not actually before him. He only possessed verbal descriptions, or illustrations in books., or notes of what he had seen. The definition of the word type must therefore be made broad enough, at least so far as it applies to the writings of the older authors, to include verbal descriptions and illustrations. Take the writings of Hübner for instance. The old calico-printer of Augsburg was a maker of picture-books. The actual specimens which he delineated in these books and to which he applied specific names are not to be found for the most part in collections which have survived his day. We are dependent for our knowledge of what Hübner intended to designate by specific names almost wholly upon the figures which he gives. These figures fortunately are generally quite recognizable. The great work of Cramer is analogous. The figures in his "Papillons Exotiques" are indeed accompanied by descriptive matter, but the original specimens from which his drawings were made in multitudes of cases cannot now be found in European collections. In these and similar cases we are compelled to accept the figure, which is extant, as representing the object in nature which the author wished to name and did name. It follows, therefore, that definitions of the word *type* should be made broad enough to include illustrations and verbal descriptions. When, therefore, I am asked to define what a type is, I should say: "It is the material actually before the author when it can be found, or the illustration given by him, or the verbal description, which he wrote, when he first gave a name to the species." Let me say in passing that in a vast percentage of cases the poorest clue to the identity of a species is a verbal description, and I, therefore, place verbal descriptions last in the order of preference. I am the more inclined to this broader definition because working in other fields than that of entomology I know by experience, especially as a paleontologist, that the author of specific and generic terms very often has nothing before him except fragments. Among paleontologists "types" often consist of nothing except a broken jaw, a crushed head, a few vertebrae, or fragments of limb-bones, some-

*) Since the foregoing opinion was expressed, N. D. Riley (*Trans. Ent. Soc. London*, LXXVI, Jan. 1929, p. 454) has demonstrated that Linnaeus had a specimen of The Monarch in his collection, which was so labeled in his own handwriting; that at the time he wrote the *Systema* he did not have a specimen of the Chinese insect (*D. genutia*); and that in Linnaeus's own annotated copy of the Tenth Edition *plexippus* is underscored by Linnaeus, indicating that he had the species in his own collection. Further, the reference to *P. chrysippus* does not occur in the original manucript of Linnaeus, till extant. The discovery by Capt. Riley of the now misplaced label seems to settle the question that the specific name *plexippus* belongs to The Monarch. W. J. Holland.

times merely a track, the impression of which has been preserved in the mud of bygone ages.

Types sometimes are very queer things. I might amuse you by telling you some things which I know, especially about types in the field of paleontological research, but I refrain.

Types are to a high degree useful in determining what a writer and first describer of a species was naming. They should be religiously preserved. No one should be allowed to tamper with them. But they are singularly liable to loss and destruction. The unhappy fall of a tray containing types may wreck them; an insidious attack of mildew, mites, or *Anthrenus* may make havoc with them; a fire may destroy the building where they are housed; some predatory collector on the sly may make away with them; a new curator, thinking to improve the appearance of the trays under his care, relegates the worn and faded things to the "duplicate file", and they are given away to school-children for their amateur collections and the world knows them no more. In an address which I made at the First Entomological Congress in Brussels I related the tragic fate of the types of Falconer's fossil mammals of the Siwalik Hills. They were thrown out by a college janitor, because they were "only a lot of worthless old bones".

In quite recent years a movement has begun to "fix the types", especially of the elder authors. The desire actuating the movement is most natural and it is desirable, if possible, to ascertain and firmly establish the exact correlation which exists between names applied by authors and the things which they intended to designate by these names. But let me utter a word of warning at this point. The task which is involved in the "fixation of types", is one which calls in most cases for great erudition, access to the entire literature of the subject, knowledge of circumstances, and the history of collections, and a most judicial and logical mind. I fear in some cases that the efforts that have been made to "fix types" are not to be accepted as final judgments, but merely as the expression of an individual opinion made by one who, actuated by a high motive, nevertheless had not the requisite information at his command. Some of the fixation of types, which has been done in recent years, leaves things "in a fix", and "confusion has been made worse confounded".

By all means conserve the types in the great historical collections. Segregate them, if you please, placing them in fire-proof and pest-proof cases. But do not become Typolaters. The latest infectious disease, to which entomologists are especially susceptible, is typolatry. The records of science should not be exclusively, or for the main part, those which are preserved in the cabinets of museums and private collectors. Important as these records are, they should not hold precedence over the printed page and carefully executed and faithful pictorial representations of species. Finally let me urge upon the brotherhood here represented the most extreme care in the preparation of verbal descriptions and in the preparation and publication of correct illustrations, among which photographic representations are to be preferred. It is said that "sunlight will not lie", but even sunlight can be made to lie, as those of us who occasionally go to the "movies" can testify. The best way of preserving

a record of types is to have them accurately figured, put upon the printed page, sent forth in editions so large that in future ages the record will be preserved, somewhere at least, in the libraries of the world. Thus there will be found in later years the means of determining what an author meant when he described a species. I am coming more and more, as the years pass over me, to coincide with the thought of my old friend, Charles Oberthür, who said: "Pas de bonne figure, pas de nom valable."

DISCUSSION.

F. Silvestri: — We all must appreciate in the highest degree the value of the type specimens which have served for the description of a new species, and we all, I think, agree also in desiring that types be preserved in the best manner possible. But we are sure that notwithstanding a strict policy in respect to the principle of absolutely good preservation, it will happen that specimens are lost for some reason or other, not excluding time. Therefore it is necessary to ask for good redescriptions of existing types by the best specialists, particularly is it necessary to urge the authorities to give permission for making microscopical preparations of old types, which, in their present state, have no longer any scientific value, and for making drawings and taking photos of others. Thus the types would become more useful to all entomologists.

We know that sometimes figures, photos, specimens in certain groups of insects are not sufficient, and that the examination of the type is indispensable. In this case it is recommendable that the possessor of the type be so kind as to compare with the type material received for such purpose or that the type be lent to Museums or very reliable persons.

As regard the categories of "types" I am of the opinion that we have enough if we accept, "type", "cotype", "paratype omotype", "paratype allotype".

I insist on the categories "omotype" and "allotype", the one meaning specimens from the same and the other from a different locality, because we all know that specimens from different localities can have, and most times have, some different character. When no type specimen any longer exists in collections, I think it should be made compulsory to refer to this particular species specimens agreeing with the original description and collected in the ame locality from which the author first described that species.

F. Muir: — Where original type material exists and no definite fixation of the type specimen has been made, either at the time of description or subsequently, a specialist working on the group should have the power to select from that material a specimen which agrees with the original description and mark it "type" and redescribe and define it in an adequate manner. If no such material exists, then it is not possible to select a type, and the commonly accepted determination of the species must prevail, having regard to locality, etc. Where the above conditions are fulfilled, no subsequent alteration should be allowed, as it can only be a matter of speculation and not of exact knowledge.

There is a fairly generally accepted category of types, which should be kept down to the smallest number possible. If they could be accepted internationally, it would be an advantage.

The use of the term "Typus", so often employed by European entomologists for material which has nothing to do with the original type material, and sometimes not even representing the original species, should be discouraged.

Types should be kept with the general collections. If conditions are such that the types are not safe in such a collection, then they should be sent to a central Museum where they will be safe. Placing them in safes out of "circulation" is not advisable, as they should be ready for comparison when working. In large Museums having many types (e. g. the British Museum) it would not be possible to segregate them and place them in safes, and even if it were possible, it would be exceedingly inconvenient for entomologists.

In Catalogues and Monographs it would be very valuable information, if the location of types were given. To make a complete compilation of the location would be a great undertaking, and the list would have to be amended as often as types in private collections changed hands.

G. Talbot. — A complete Catalogue of existing type specimens is of great utility. All museums should publish a list of their own types, and these lists should be available at the Institute controlling the publication of the name Catalogue. The names of all private collections, where the type material is too small for separate publication, should send in a list to be embodied in a General Catalogue of Types.

Before such Catalogues are published, general agreement must be reached on the method of designating type specimens. We propose that the list should included at least Holotype, Allotype, Neallotype, and Paratype specimens.

A further desideratum is a pictorial record of all types maintained at a central institute. Anyone then, on payment of a small fee, could obtain a photograph of any desired type. Possibly it may be found more practical to arrange that every museum should keep its own record, and that private or small collectors should furnish a central institute with a photographic plate made from the type specimens.

Agreement would have to be reached as to the proper method of depicting the specimen.

Forum on Problems of Taxonomy: Discussion on Types;*)

introduced by

Dr. James Waterston, British Museum (Natural History), London.

Appended to the courteous invitation of our Secretary that I should open this discussion "from the European side" was an equally firm request for a resumé (by return post) of the remarks I proposed to make. It was perhaps fortunate for myself that I at once obediently sat down and committed to paper certain very definite and possibly crude answers to the questions propounded for, although the subject matter of this discussion has necessarily engaged my thoughts during the period in which it has been my privilege to serve upon the British National Committee on Entomological Nomenclature (so much so indeed that the answers appeared to be self evident), I must confess that my confidence was somewhat shaken when, after many interrogations, I realised how diverse were the views, both theoretical and practical, on these matters, of many zoologists one of whose main concerns is the production of systematic descriptions.

One authority to whom I brought the questionnaire had not realised the necessity of the existence of types. "There is my description — what more does anyone want?!" Others — and they were many — took up the position that all the examples before an author, considered by him to belong to the same species and mentioned in the original description, constitute the type, or are to be equally regarded as types. We as entomologists cannot assume either of these attitudes. We claim no infallibility for our most laborious and apparently exact diagnoses, and if, whether from temperamental reasons or of settled policy, we label described material as 'cotypes' we are merely shifting a necessary task on to other shoulders. Our real problem is to decide by what material our concepts and descriptive work are to be judged. For this reason it seems to me that the most far reaching question set in this discussion is "What categories of types are useful and advisable?" I therefore take this first.

I. — In attempting to clarify our minds on this subject and avoiding at the same time any trespass on the discussion devoted to the theory of nomenclature — a field into which one might easily stray —, we cannot do better, I think, than consider briefly the practice of writers who give descriptions to the scientific world. Two quite opposite tendencies are in my mind.

(a) — The bulk of systematic workers conscientiously set about the task of detailing the distinctive features — morphological, ecological, physiological or distributional — presented by the organism before them. What they as individuals achieve may vary enormously in value. Naturally the worker with a well stored mind and a quick comparative eye will succeed

*) Cf. also the preceding article by Dr. W. J. Holland.

best in arriving at and making intelligible to others the species concept sought for. Having formulated his ideas, he proceeds to select an individual example or type by which the soundness of his work may be tested.

(b) — I trust that no one will suspect me of uncharitableness if I describe the second type of worker simply as he appears to me. He seems to take a map divided into more or less arbitrary areas, or a group of hosts, or islands, isolated lakes, and so on, and to proceed in the most mechanical way to determine where species should and so must occur. When an organism is received from one of these prepared pigeon-holes, out comes the nomenclatorial pepper pot and the thing is done. The description may be negligible, but no apology is offered. Indeed, the attack is more likely to be carried into the territory of the more concientious worker.

The most detailed study of limited material fails to achieve its purpose. Real description is impossible so long as any major portion of the field remains unexplored, and while such conditions hold it is better frankly to publish preliminary diagnoses which, even if they do not contribute an iota of fundamental importance to science, at least draw attention to properly labelled material which must later be considered as a whole. We need not argue the pros and cons of the positions just outlined. What I do want to emphasise is that both lead to the same result, viz. the selection of an individual organism for association with a name. For, if the systematist who aims at ultimate definition is logically compelled to indicate how that definition may be tested, a *fortiori* one who regards his function as perhaps after all only a kind of provisional labelling, must see to it that his labels are unequivocally attached.

Now, if you bear this in mind and regard species-type-fixation as the natural ending of the process of description you will have no difficulty in deciding what should be regarded as valid type categories. The ultimate principle in the matter is that the term 'type' should be applied only to material considered by the author at the time of description. If the author leaves his work unfinished by neglecting to select a specimen for special association with the description and name, the individuals before him are equivalent cotypes. When one of these has been selected, either by the author or a subsequent student, it becomes the Type sive Holotype of the species, and the rest by elimination become Paratypes, unless deliberately excluded (e. g. unnamed vars., races or atypical examples). These three terms constitute in my opinion the only valid type categories. One might simply on the ground of convenience add the term 'Allotype' to denote a selected exemplar of the sex complimentary to the Holotype. Most of us do this, yet strictly speaking the use of 'type' here argues a confusion of thought. A type is an exemplar of a species, not of a sex, nor of any circumstance relating to a species, however important that circumstance may seem to be. If you dissent you must be prepared to admit an infinite number of 'types' for every described organism. You will have locality types, seasonal and sexual types, larval, pupal and egg-types, host types, mimetic phase types, etc., involving a curious and ponderous terminology. Each of these phase-types again will have appended to it subordinate categories indicative of the way in which selection may be made. Under such conditions the use and interpretation

of the 'type' categories might easily become a more formidable matter than classification of the organisms themselves. From such a fate only the vigorous application of Occam's razor can save us. *'Entia non multiplicanda sunt praeter rationem'* and the 'ratio' or ultimate principle of type fixation, as has already been suggested, severely limits the number of real type categories.

It may be urged, however, that the many neologisms by which type terminology has recently been 'enriched' have resulted from conditions to which I am doing scant justice. No one would dream of making a 'neotype' or relying on a 'topotype' unless the original type material had been lost. To which, with all sympathy, I should say that when the original material of a description has perished there can be no 'type', and the interpretation of a name will depend on clues afforded by the printed word.

II. — Here I think one comes naturally to consider the question of the fixation of type specimens of the older authors and frankly I feel unqualified to suggest any broad principle of procedure except this, that the task must be undertaken in each case by the trained specialist. He may have comparatively little to do. Where an old collection contains single or few specimens under its names, checking up with the original descriptions may quickly be accomplished. On the other hand, labels may have been altered or disappeared; specimens may have been discarded or replaced, and, in a hundred ways, doubts may legitimately arise. Only in one case is a specialist occupied in type fixation clearly absolved from any exercise of his individual judgment, i. e. when he finds in a collection a specimen with a definite bibliographical reference. In all other cases he must resign himself to undertake a careful and detailed examination of the available material, applying the relevant laws of nomenclature as his common sense serves him. A word of warning may be not unseasonable here. Perplexing as a fully labelled collection may sometimes be, one which presents the enquiring specialist with specimens and pins sets an infinitely harder task. For there the morphology of each individual specimen, their collective history and any relevant circumstances, must be taken into account. Faced with such a task the specialist may be tempted to cut the knot by arbitrary selection. Such fixation may ultimately be necessary, but against its premature exercise one must remember that the right of a reviser is not absolute, and that a second reviser may quite correctly upset careless decisions if adequate reason can be shown.

When the original collection has been lost and descriptions are wholly or partly unintelligible, the matter of type fixation or, as I prefer to say, 'description intrepretation', must likewise remain with the specialist. In revisional work the fate of such names is usually relegation to an appendix, but it is much better, if there is the slightest clue, to dispose of a name as a synonym. In this position the name has an intelligible meaning, and few will cavil at such a decision.

Yet there might be a more excellent way. To place a name in an appendix is too often a gesture of despair. There is no reasonable prospect, let us suppose, of the application of the name ever becoming plain. Has not the time now come when systematists, in their own interests, should limit the life of such nomenclatural and entomological puzzles? When a

diagnosis is patently insufficient and no type material exists, should we not simply say that, after a term of years to be agreed upon, the accompanying name should lose all nomenclatural standing, except of course that, as a combination, it should no longer be available for use?

III. — I come now to a much more practical matter — the recording and publication of all essential information regarding existing types. Whatever interests have brought us together, however specialised may be our studies, all of us should be united in demanding that the main facts about types should be made as widely available as possible. Museums have an obvious duty to discharge here to the specialist who in his researches is held up, time and again, by uncertainty as to the location of types. Inability to see types delays or prevents certain determination with automatic repercussion on the work of the applied entomologist. This point need not be elaborated.

Communication of the information desired however, if that implies publication, will be difficult, at least for European countries, for many a long day, and I can see no prospect of launching any large work dealing with type location, etc., through the existing channels. Much, however, might be done without publication. Owners or curators, if they cannot keep a complete catalogue of the collections under them, could at least card index their 'types' and the mutual exchange of such cards would go a long way towards relieving the present trouble.

IV. — The last matter on which I shall venture to offer an opinion is in answer to the question "Under what conditions should types in collections be kept and how are they to be made available for study?" To the first part of the query I should say that where the collection is small, or, if larger, seldom consulted, there is no need to isolate types. When, however, collections are in daily use to supply an insatiable demand for names, when drawers are being constantly jarred and shaken as will occur even with careful handling, the isolation of types may become a necessary safeguard. This is the merest common sense. I do not regard types as sacrosanct or as in any respect more important than a good description. Nor have I the slightest wish to see them last for ever! But one would like to ensure for types a life long enough to allow their essential characters to become generally known. In many groups, indeed, this stage of knowledge has already been attained so that if types were lost to-morrow, science would be none the poorer. There are species of mammals, birds, fishes, butterflies, bees and wasps, whose types no one wishes to see except as historical curiosities. As science grows so does the importance of the type decrease, until we can see it in its true light, as a crutch which, if for a time affectionately cherished, can ultimately be discarded. This may be but a half truth, yet it requires to be stressed. The danger now is that a smug dependance on types may replace the old thirst for knowledge, and the constant effort to formulate ever more clearly and accurately the species concepts of the organisms in which we are interested. Systematic science ceases to progress when this effort is consciously relaxed. And for such a loss neither types nor the most elaborate system of type terminology can be any substitute. We might still produce execrable descriptive work with all the types of the entomological fauna duly labelled, card indexed, and with full data, before us. *Absit omen.*

Should then types be isolated in collections? While types remain imperfectly studied they must be kept as carefully as possible, and in view of the increased handling to which types in a general museum collection are now subjected, I am in favour of their isolation where such isolations will clearly afford additional protection. Now isolation involves the provision of extra accommodation and will perhaps entail extra curatorial work in indexing and labelling, and this policy should not be adopted without some thought. It does not seem to be applicable to every group. I do not see, e. g. what extra security isolation would ensure when the specimens in a collection are uniformly mounted in balsam, e. g. in such groups as Mallophaga, Anoplura, Aphidae, Coccidae and Strepsiptera. On the other hand, the isolation of types might commend itself to the curator of Lepidoptera or Tipulidae. Decisions of this sort, however, may safely be left to those most concerned. The only objection I can see to a policy of isolation, where thought to be necessary, might come from the numerous students whose only care in consulting a collection is to find names for their material. The objection might be raised that they must see types. It would occupy too much of your time to give you my full reason for overruling this plea; I can only say I am convinced that for naming purposes a specimen carefully compared with the type should be sufficient. The visiting specialist, of course, should have access to the type collection.

There still remain some subsidiary points suggested for discussion. What facilities should be given by museums for the study of types? Should types be loaned or should the student be compelled to visit various centres? I am at a double disadvantage in trying to frame an answer here inasmuch as I belong to an Institution which has already drawn a definite line in the matter (so that anything offered may seem an *ex parte* statement), and also because there is a prior but cognate question on which agreement is necessary, viz. *Where* should types be deposited? If you are prepared to say "In any Museum" — then no general rule can be laid down.

It seems to me that small local museums, with no specialist in charge of types, have an obvious duty to loan out such specimens, yet they may be unwilling to do so with the result that tools indispensable to the specialist, may stand idle, and scientific progress be arrested. The matter now raised, however, might well afford a discussion in itself, and I shall not further touch on it except to suggest that this meeting might well record a strong protest against the bequeathing of types to institutions where neither their proper care nor continuity of research can be guaranteed. An effort might also be made to induce local museums either to present their types to, or to deposit them on loan, in some more central museum.

As regards the large national museums, I am not in favour of the loaning of types. In the last analysis this is a matter of expediency. The sending out of types would be laborious. Annoying gaps would be made in series while specimens were on loan, and there is the real danger of injury in transit. It is true that to visit the larger museums for study purposes will frequently involve long journeys, but time so spent has many compensations, not the least of which is the formation of personal ties with fellow workers in a common task.

A Comparison of the Systems of Nomenclature that have been applied to the Radial Field of the Wing in the Diptera.

Charles P. Alexander,

Massachusetts Agricultural College, Amherst, Mass., U. S. A.

(With Plates I, II, III.)

The importance of the wing-venation as an aid to a knowledge of the taxonomy and phylogeny of the Diptera is now fully appreciated by all workers on the group. Of all the fields of the wing, the radial, because of its wide extent and relatively numerous veins, would appear to be the most important.

It is only in the two most generalized groups of recent Diptera, the *Tanyderidae* and *Psychodidae*, that the full complement of five radial veins is retained. In all other groups within the order, the field has undergone reduction and the problem of exactly which of the veins have been retained becomes of more than ordinary importance. Edwards (1926: 125—127) discussed the question as it concerns the phylogeny of the Nematocera in the light of the knowledge of the subject then available.

Three distinct systems of terminologies and no fewer than five separate interpretations of the radial veins have been proposed by various workers on the order. The purpose of the present paper is briefly to compare these various interpretations as they apply to the radial field, and, especially, to call wider attention to certain of the more recently proposed suggestions.

One of the earliest, and still one of the most widely used systems of nomenclature of the Dipterous wing is that of Loew (1862) *). This system did not originate with Loew, but was gradually evolved from the work of earlier students of the order, as Meigen and Wiedemann. It received a great impetus from its adoption by Williston (1908) and is still widely used by descriptive Dipterologists in many parts of the World. It is highly unfortunate that Loew selected the Muscoidean type of wing as primitive, with the necessary result that serious complications ensued when families of Diptera with a more complete venation were studied. The Loewian or numerical system still suffices for descriptive purposes, but has a fundamental weakness in its artificiality and the consequent impossibility of determination of strict homologies in very different types or its use as an aid to phylogenetic studies. According to this system, the radial field is made up of the first three longitudinal veins (Plate I, fig. 1). The cells of the wing are the marginal, submarginal and first posterior, but the relative number and position of

*) Dates in parenthesis refer to the Bibliography at the end of this paper.

the first two have been in dispute and have resulted in some confusion in descriptive work (as Philippi, 1865; Osten Sacken, 1869; Williston, 1906). Still more recent workers (as Brunetti, 1912) have continued to modify this system and have unquestionably been influenced in this course by a knowledge of the other and more natural terminologies discussed later.

The second system, the Schinerian, was elaborated by Schiner (1862), chiefly from the earlier work of British and French workers on the order. More recent students, as van der Wulp and Verrall (1901), adopted this terminology and it has thus received wide attention. As was the case with the first-mentioned system, the Schinerian is hampered by its serious artificiality, the continued confusion between true crossveins and deflections of longitudinal veins and the consequent difficulty of obtaining true homologies of parts when a considerable range of venational types are to be considered (Plate I, fig. 2). According to this system, the 1st longitudinal vein of Loew is the subcostal vein, the 2nd longitudinal the radial, the 3rd longitudinal the cubital vein.

A third system, conveniently called the Comstock-Needham or Uniform system, was adapted to the orders of winged insects by Comstock and Needham (1898—1899; Comstock, 1918). Like the two preceding, this was the result of building upon a frame-work laid down by earlier workers along this line, in this case more especially Josef Redtenbacher. This system not only gave to the world a much simpler terminology for the veins and cells of the wings of all winged insects, but, since it was founded on a strict morphological basis, furnished an all-important tool for the study of phylogenetic relationships. The entire radial field was designated by the symbol *R*, with sub-figures to designate the separate veins and cells (Plate I, fig. 3). The Comstock-Needham system is too well known to require further comment, since it has been adopted by the authors of virtually all recent text-books on entomology.

The important studies of Tillyard (1918, 1926), insofar as they affect the Diptera, modify the medial and cubital fields of the wing, but make no changes from the accepted results of Comstock and Needham for the radial field (Plate I, fig. 5).

The first proposal to modify this latter field of the wing in the Diptera was that of Shannon and Bromley (1924), where, from a study of the families of the lower Brachycera, the authors came to the conclusion that the upper branch of the sector, R_{2+3}, is a branched vein, but that the posterior branch, R_3, has been deflected caudad and become permanently fused with the anterior branch of the posterior fork, R_4, to form a fusion R_{3+4}. In the majority of the members of the Brachycera there remains no trace of this basal connection, but in a considerable series of genera and species in many families (as *Leptidae, Tabanidae, Nemestrinidae, Mydaidae, Asilidae, Therevidae* and *Bombyliidae*), the missing vein is represented either by a complete transverse element, R_3 (*Asilidae: Promachus* and some *Erax; Bombyliidae: Exoprosopa* and some *Anthrax*) or by evident spurs of veins (Plate I, fig. 4).

A second proposal to modify the radial field of the Diptera is that of the present writer. A consideration of this interpretation, first applied to a single tribe of the *Tipulidae* (Alexander, 1918) and more recently (Alexander, 1927) applied to other families of the Nematocera, furnishes the material for the remainder of the present report. It should be observed that Dr. Tillyard came to almost identical conclusions as a result of his studies on fossil insects (Plate I, fig. 5).

In the most generalized group of living Diptera, the *Tanyderidae*, the radial sector is dichotomously twice branched. In the *Tanyderidae*, as well as the closely allied *Psychodidae*, the four branches of the sector are retained, but in all higher Diptera one or more of these branches have been lost, chiefly by fusion of veins, but in a certain number of cases by atrophy of the elements concerned. The contention of the present theory is that the radial crossvein (r) has never been developed in the Diptera, the element that has been so interpreted in the past being an upward deflection of R_2 that has assumed a transverse position.

The two phenomena that have taken place in the radial field of the Diptera may be briefly discussed as follows:

(1) The cephalization of vein R_2.

In the generalized families of Diptera, as the *Tanyderidae (Eutanyderus wilsoni* Alexander, Plate II, fig. 1), vein R_2 is a fully developed longitudinal vein that lies between and runs parallel to veins R_1 and R_3, attaining the wing-margin as a separate unit. It should be emphasized that in these primitive groups, there is never any indication of the so-called radial crossvein. In all higher families, vein R_2 has swung cephalad and become permanently attached to R_1, forming a short to longer fusion, R_{1+2}. The discovery of a very generalized Tipulid, *Tricyphona protea* Alexander (Plate II, fig. 2), gave the first clue to the true interpretation of this venation (Alexander, 1918). In this insect, R_2 is still a longitudinal element, but the extreme outer end has become permanently attached to R_1. A still more recent discovery, *Tricyphona formosana* Alexander (Plate II, fig. 3), has this backward fusion of R_1 and R_2 still more extensive, forming an intermediate condition that leads to the transverse position of the vein R_2 that is common in the family *Tipulidae* (as *Tricyphona arisana* Alexander, Plate II, fig. 4) and some allied groups and has earlier been interpreted as being the radial (marginal) crossvein. Certain groups of the order that are now known to be very generalized, as the *Ptychopteridae* and *Trichoceridae*, exhibit this feature of the cephalization of R_2, but almost all higher groups have lost the transverse element, R_2, by atrophy. As far as known to the writer, R_2 persists in the Diptera only as high in the scale as the Nemestrinid genus *Nycterimyia* Lichtwardt. The *Ptychopteridae,* although an isolated group, are still placed in the vicinity of the *Tanyderidae* and the occurrence of this phenomenon in the Psychodoidea is of great importance.

(2) The capture of vein R_4 by R_{2+3}.

In the generalized Diptera *(Tanyderidae,* Plate II, fig. 1; *Tricyphona,* spp., Plate II, figs. 2—4), as elsewhere in primitive types in certain of the higher orders of insects, the radial sector is dichotomously twice forked. Except in these scattered lower groups of Diptera, the dichotomy has been lost, the upper fork of the primitive sector being obliterated by the capture

of its anterior branch, R_2, by vein R_1, in the manner outlined above (under 1). The lower fork retains its dichotomous nature in a few groups, appearing as a very deep fork, with a correspondingly shortened petiole (Plate II, figs. 2—4). As will be indicated later, the apparent dichotomous nature of the posterior fork of the sector in the lower Brachycera (Plate III, figs. 9, 10) has been brought about secondarily. The dichotomous effect of this fork is lost by the anterior branch, R_4, becoming more intimately attached to and permanently captured by R_{2+3} to form a short to longer fusion, R_{2+3+4}. This apparently unique condition has been brought about in a relatively simple manner by a slight shifting of the veins at the end of the sector. The condition was discussed at some length by *Needham* in his classic study of the venation of the *Tipulidae* (1908: 225—226, fig. 14) and has been considered more superficially by other recent workers on this family.

The first appearance of this phenomenon in the Diptera is in the subfamily *Phlebotominae* of the *Psychodidae* (Plate III, fig. 1), where, because of the lack of the cephalization of vein R_2, the venation of the sector appears pectinate. In the lowermost Brachycera (many *Asilidae, Nemestrinidae* and *Bombyliidae),* as already discussed under the Shannon-Bromley interpretation, the basal connection of R_4 is still retained as a complete element in many genera *(Asilidae: Pogonosoma, Promachus* (Plate III, fig. 8), *Alcimus, Philodicus, Erax,* etc.; *Nemestrinidae: Exeretoneura, Trichopsidea, Nycterimyia, Cyclopsidea,* etc.; *Bombyliidae: Hyperalonia, Exoprosopa, Pantarbes, Toxophora, Lordotus* and many others). In still other very numerous genera and species, this basal section of R_4 is indicated by a distinct spur (as in *Chrysopila,* Plate III, fig. 9), usually representing the posterior portion of the element, jutting cephalad into cell R_3. Dr. Friedrich Hendel has called my attention to the fact that a trace of the basal section of R_4 even persists as high in the phylogenetic series as the Ortalid genus *Pyrgota,* where its position is indicated by a small spur on R_3, jutting caudad into cell R_3. It should be noted that in all families of the Brachycera in which the free tip of R_4 is retained *(Leptidae* through the *Empididae,* Plate III, figs. 8—10), that this element is permanently connected with vein R_5 by a supernumerary crossvein (s) that is so well established as to simulate the base of vein R_4. A supernumerary crossvein in cell R_4 is found in several generalized Diptera *(Tanyderidae: Nothoderus, Tanyderus, Mischoderus; Tipulidae: Polyangaeus, Heterangaeus)* and its retention in this strategic position in the lower Brachycerous groups in not surprising.

In the accompanying diagrammatic series of figures (Plate II, fig 8, A—J), an attempt has been made to illustrate the two tendencies shown in the radial field of the Diptera. These figures are in all cases based on actual genera and species.

Fig. A. Primitive type of radial sector of the *Tanyderidae.*

Fig. B. The type of *Tricyphona protea;* R_2 longitudinal in position but its tip permanently captured by R_1; a shortening of R_{4+5}.

Fig. C. The type of *Tricyphona formosana;* R_2 oblique in position, a long backward fusion of R_{1+2}; R_{4+5} very short to lacking, cell R_4 thus being sessile to subsessile.

Fig. D. The type found in many Pediciine *Tipulidae.* R_2 subtransverse; R_4 permanently transferred to the upper fork of the sector, R_{2+3}, forming a short R_{2+3+4}.

Fig. E. The type common in Eriopterine and Hexatomine *Tipulidae; Trichoceridae.* R_2 transverse, simulating a crossvein; fusion of R_{2+3+4} extensive.

Fig. F. R_2 atrophied, as in all higher Diptera; R_{2+3+4} extensive.

Fig. G. R_2 atrophied; R_{2+3+4} extensive; R_4 connected with R_5 by a supernumerary crossvein (s) (many of the lower Brachycera, as *Asilidae* and *Bombyliidae).*

Fig. H. R_2 atrophied; basal section of R_4 atrophied, permanently attached to R_5 by a supernumerary crossvein (s) (majority of the lower Brachycera, through the *Empididae).*

Fig. I. R_2 atrophied; R_{4+5} simple, due either to atrophy of the distal section of R_4 (in which case the posterior branch should be interpreted as being R_5) or a fusion of R_4 and R_5 to the wing-margin (in which case the posterior branch should be interpreted as being R_{4+5}) (condition found in the majority of the higher Brachycera, *Dolichopodidae* through the Muscoidea). Exactly the same result is obtained in several Nematocera by a fusion to the wing-margin of elements R_3 and R_4 (as in *Tipulidae: Gonomyia,* subgenus *Lipophleps; Eriocera,* subgenus *Cladolipes).*

Fig. J. R_2 and R_{2+3} atrophied. The single persistent branch of Rs is here interpreted as being R_5, indicating the loss of vein R_4 by atrophy. In some cases, at least, the result is probably obtained by a fusion of veins R_4 and R_5 to the wing-margin. The branches of radius between the anterior branch, R_{1+2}, and the posterior one, R_5, are lost in a variety of ways. In some Nematocera, as the *Blepharoceridae,* R_3 in the most primitive genus, *Edwardsina* (Plate 3, fig. 3) is a long element that extends generally parallel to R_4 and reaches the wing-margin as a separate unit. In all other genera of this family, R_3 is fused backward from the margin with R_{1+2} the element finally disappearing in the axil of the sector (as in the more specialized species of *Bibiocephala).* The main axis of radius in all higher *Blepharoceridae* should be interpreted as being R_{1+2+3} .In the higher *Anisopodidae* and especially the *Mycetophilidae,* R_4 is lost either by atrophy or by fusion with R_3 to the wing-margin. The surviving element, here interpreted as being R_3 alone *(Anisopus,* Plate III, fig. 5) then forms a backward fusion with R_{1+2}, quite as in the *Blepharoceridae.* Very numerous instances of the loss of branches of the sector occur throughout all the higher families and most of the more reduced groups must be studied as separate entities from a strict phylogenetic standpoint.

In the earlier discussion of this interpretation (Alexander, 1927: 57—69), the writer attempted to retain the true radial crossvein (r) in a small group of the *Tipulidae* (Subfamilies *Architipulinae, Tipulinae* and *Cylindrotominae;* Subfamily *Limoniinae,* Tribes *Limoniini* and *Lechriini).* Letters were received from Drs. Tillyard, Mackerras and Tonnoir indicating the improbability of this explanation and offering suggestions by which the venation of all the Diptera were brought into harmony. The original interpretation is shown (Plate II, fig. 5), together with the suggested interpretation which must now be held to be correct (Plate II, fig. 6). It can be seen from this comparison of figures, that in

the groups in question, the free tip of Sc_2 is preserved as a distinct element that reaches the margin. The earlier interpretation (Fig. 5) may be brought into harmony with the now accepted view (Fig. 6) by making the following changes of veins in the original paper on this subject (Alexander, 1927, figs. 43—89):

First section of R_1 becomes $Sc_2 + R_1$.
Distal section of R_1 becomes Sc_2 (free tip),
Radial crossvein (r) becomes R_1.
R_2 becomes R_{1+2}.

The groups under consideration present some very puzzling features and the exact interpretation of the radial field may remain in dispute for some time. The diagrams of the wing of *Tanyptera* (Plate II, figs. 5—7) serve to illustrate this problem. Unlike all other members of the Diptera discussed herein, the species of these few subfamilies show no sign of the capture of R_4 by R_{2+3} and the venation has accordingly been interpreted as representing a fusion to the wing-margin of the elements R_4 and R_5. It must be admitted that there is not a bit of evidence that such a fusion has taken place, but there appears to be no other logical way of interpreting this venation. Mr. Hendel *(in litt.*)* is unwilling to accept the interpretation as given (Plate II, figs. 5 or 6), but believes that the terminologies as given herein for the remaining Diptera should be applied to the present groups. This course certainly appears logical since it would then bring all members of the Order into harmony. However, the results of such an application of names in the present groups (Plate II, fig. 7) results in such apparently impossible behavior of some of the elements (as R_2) that the present writer feels reluctant to believe that this explanation is the correct one. More evidence must be forthcoming before the last word will have been said on this particular subject.

Literature cited.

1. Alexander, C. P. 1918 — A new interpretation of the wing-venation of the Pediciine Crane-flies (Tipulidae, Diptera); Ent. News 29, pp. 201—205, pl.
2. id. 1927 — The interpretation of the radial field of the wing in the Nematocerous Diptera, with special reference to the Tipulidae. Proc. Linn. Soc. New South Wales, 52: 42—72, 92 figs.
3. Brunetti, E. 1912 — The Fauna of British India. Diptera Nematocera, pp. 8—16, fig. 3.
4. Comstock, J. H. 1918 — The wings of insects, pp. 1—430, 427 figs., 10 pls.
5. id. and Needham, J. G. 1898—1899 — The wings of insects: Amer. Nat., 32, pp. 43, 81, 231, 237, 240, 243, 249, 253, 256, 335, 413, 420, 423, 561, 769, 903 (1898); 33, pp. 118, 573, 845, 851, 853, 858 (1899).
6. Edwards, F. W. 1926 — The phylogeny of Nematocerous Diptera: a critical review of some recent suggestions. III. Internat. Entomol.-Kongress, 2, pp. 111—130.
7. Loew, H. 1862 — Monographs of the Diptera of North America. Part I. Smithson. Miscell. Coll., vol. 6, pp. xv—xxiii, figs. 3.
8. Needham, J. G. 1908 — Venation of the wings of Tipulidae; 23rd. Rept. State Entomol. N. Y. for 1907, pp. 217—238.
9. Osten Sacken, R. 1869 — Monographs of the Diptera of North America. Part IV. Smithson. Miscell. Coll. No. 219, pp. 31—35, fig.

*) Since published: Die Tierwelt Deutschlands, 11. Teil, Zweiflügler oder Diptera, II. Allgemeiner Teil, pp. 1—135, 1928.

10. Philippi, R. A. 1865 — Aufzählung der Chilenischen Dipteren; Verh. zool.-bot. Ges. Wien, 15, pp. 602—617.
11. Schiner, J. R. 1862 — Fauna Austriaca. Die Fliegen (Diptera), 1, pp. x—xv, pl. 2.
12. Shannon, R. C., and Bromley, S. W. 1924 — Radial venation in the Brachycera; Insec. Inscit. Menst., 12, pp. 137—140, pl. 5.
13. Tillyard, R. J. 1919 — The Panorpoid Complex. Part 3. The wing-venation; Proc. Linn. Soc. New South Wales, 44, pp. 533—718.
14. id. 1926 — The Insects of Australia and New Zealand, pp. 333—379.
15. Verrall, G. H. 1901 — Syrphidae of Great Britain. British Flies, 8, pp. 1—691, figs. 24, 84 and 124.
16. Williston, S. W. 1906 — Some common errors in the nomenclature of the Dipterous wing. Psyche, 13, pp. 154—157, fig.
17. id. 1908 — Manual of North American Diptera, Ed. 3, pp. 37—43, figs. 12—20.

EXPLANATION OF THE PLATES.

Symbols:

1—6 = 1st to 6th longitudinal veins (Loew).
A = Anal veins, Analis.
bax = anterior basal crossvein (Loew).
A. I. = Anterior intercalary vein (Loew).
Al. = Alula.
Aux. = Auxiliary vein (Loew).
C = Costa.
Cu = Cubitus (Comstock, Needham).
Cub = Cubitalis (Schiner).
Em = Externomedius or Discalis (Schiner).
h = humeral crossvein.
IM = Internomedius or Posticalis (Schiner).
M = Media (Comstock-Needham).
m = medial crossvein.
Med = Mediastinalis (Schiner).
m-cu = medial-cubital crossvein.
ox = ordinary crossvein (Schiner).
pbx = posterior basal crossvein (Loew).
P. I. = Posterior Intercalary vein (Loew).
px = posterior crossvein (Loew, Schiner).
R = Radius (Comstock-Needham).
Rad = Radialis (Schiner).
r-m = radial-medial crossvein.
Rs = Radial sector.
s = supernumerary crossvein (Alexander).
Sc = Subcosta (Comstock-Needham).
Sub = Subcostalis (Schiner).
sx = small crossvein (Loew).

PLATE I.

Series of wings of Tabanus, sp., to illustrate the following systems of wing-venation:

Fig. 1. Loew (1862).
2. Schiner (1862).
3. Comstock-Needham (1898).
4. Shannon-Bromley (1924).
5. Alexander (1927).

PLATE II.

Fig. 1. Wing of *Eutanyderus wilsoni* Alexander *(Tanyderidae)*.
2. Wing of *Tricyphona protea* Alexander *(Tipulidae)*.
3. Wing of *Tricyphona formosana* Alexander *(Tipulidae)*.
4. Wing of *Tricyphona arisana* Alexander *(Tipulidae)*.
5. Diagram of the radial field of *Tanyptera* sp. *(Tipulidae)*, with the venation interpreted according to Alexander (1927).

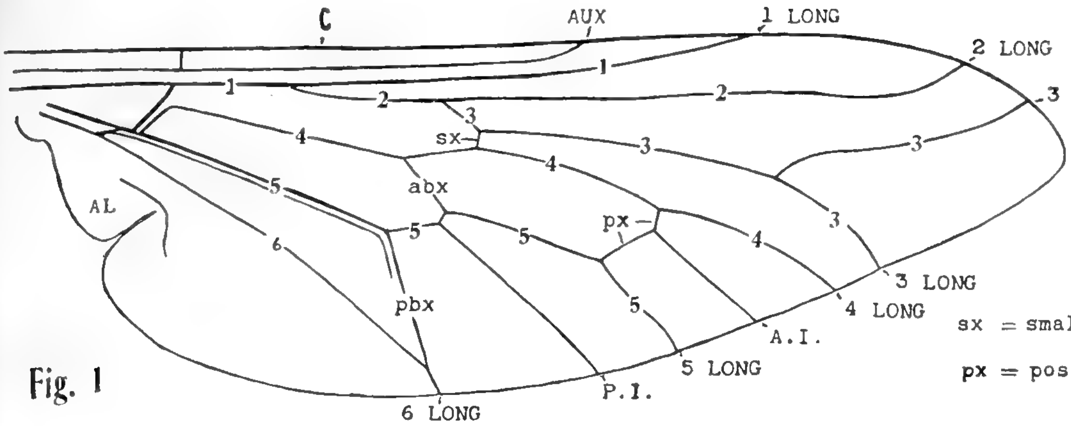


Fig. 1

LOEW (1862)

C = COSTAL AUX = AUXILIARY
1 — 6 LONG = LONGITUDINALS
A. I. = ANT. INTERCALARY
P. I. = POST. INTERCALARY
AL = ALULA
sx = small x-vein abx = ant.bas.x-vein
px = post. x-vein pbx = post.bas.x-vein

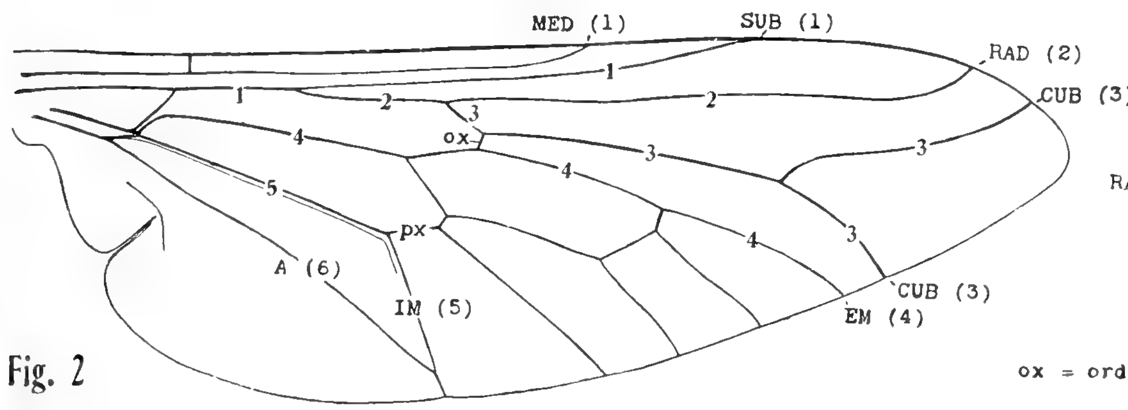


Fig. 2

SCHINER (1862)

C = COSTA
MED = MEDIASTINALIS
SUB = SUBCOSTALIS
RAD = RADIALIS CUB = CUBITALIS
EM = EXTERNOMEDIUS (DISCALIS)
IM = INTERNOMEDIUS (POSTICALIS)
A = ANALIS
ox = ord. x-vein px = post. x-vein

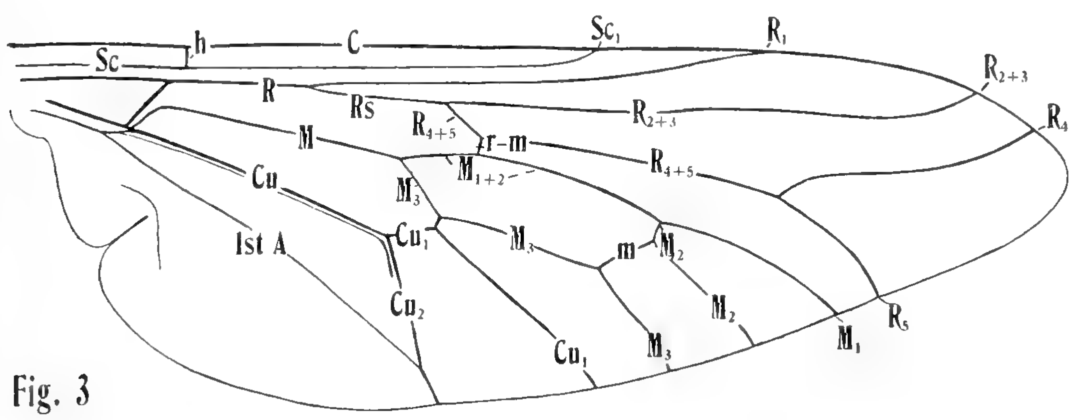


Fig. 3

COMSTOCK-NEEDHAM (1898)

C = Costa
Sc = Subcosta
R = Radius
Rs = Radial Sector
M = Media
Cu = Cubitus
A = Anal

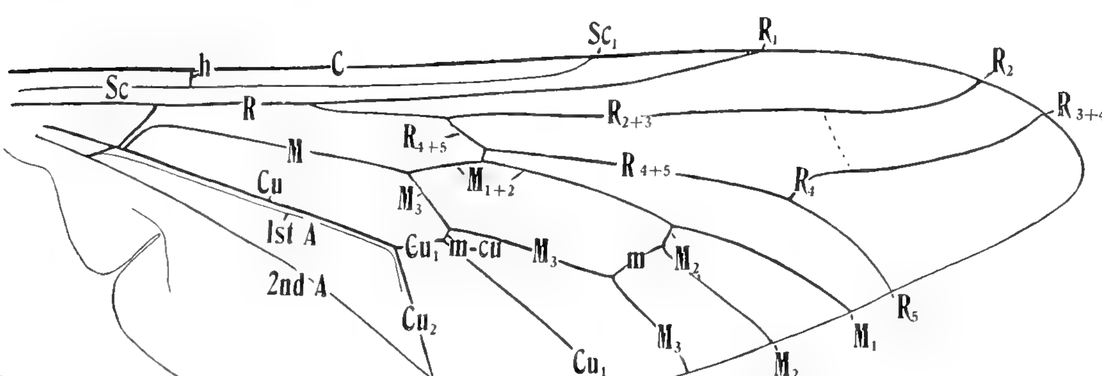


Fig. 4

SHANNON-BROMLEY (1924)

h = humeral x-vein
r-m = radial-medial x-vein
m = medial x-vein
m-cu = medial-cubital x-vein
R_4 = Radius $_4$

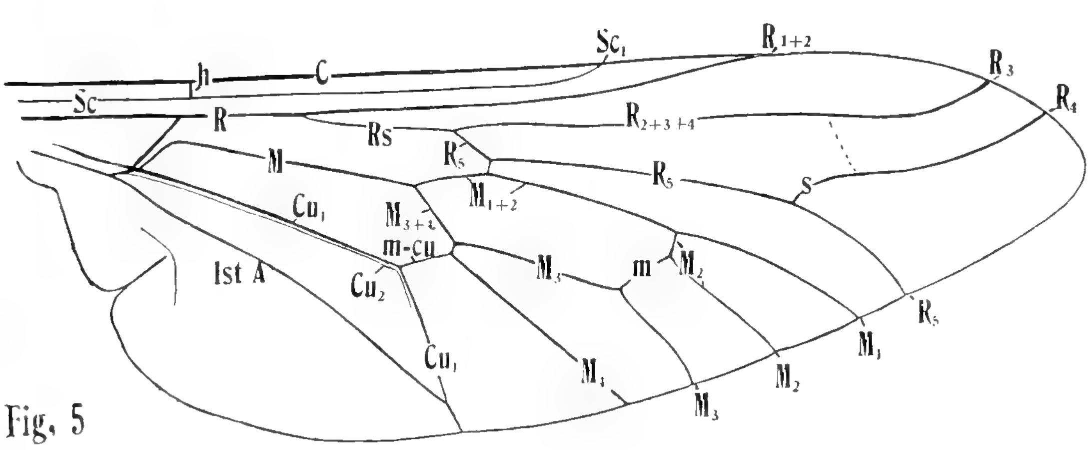


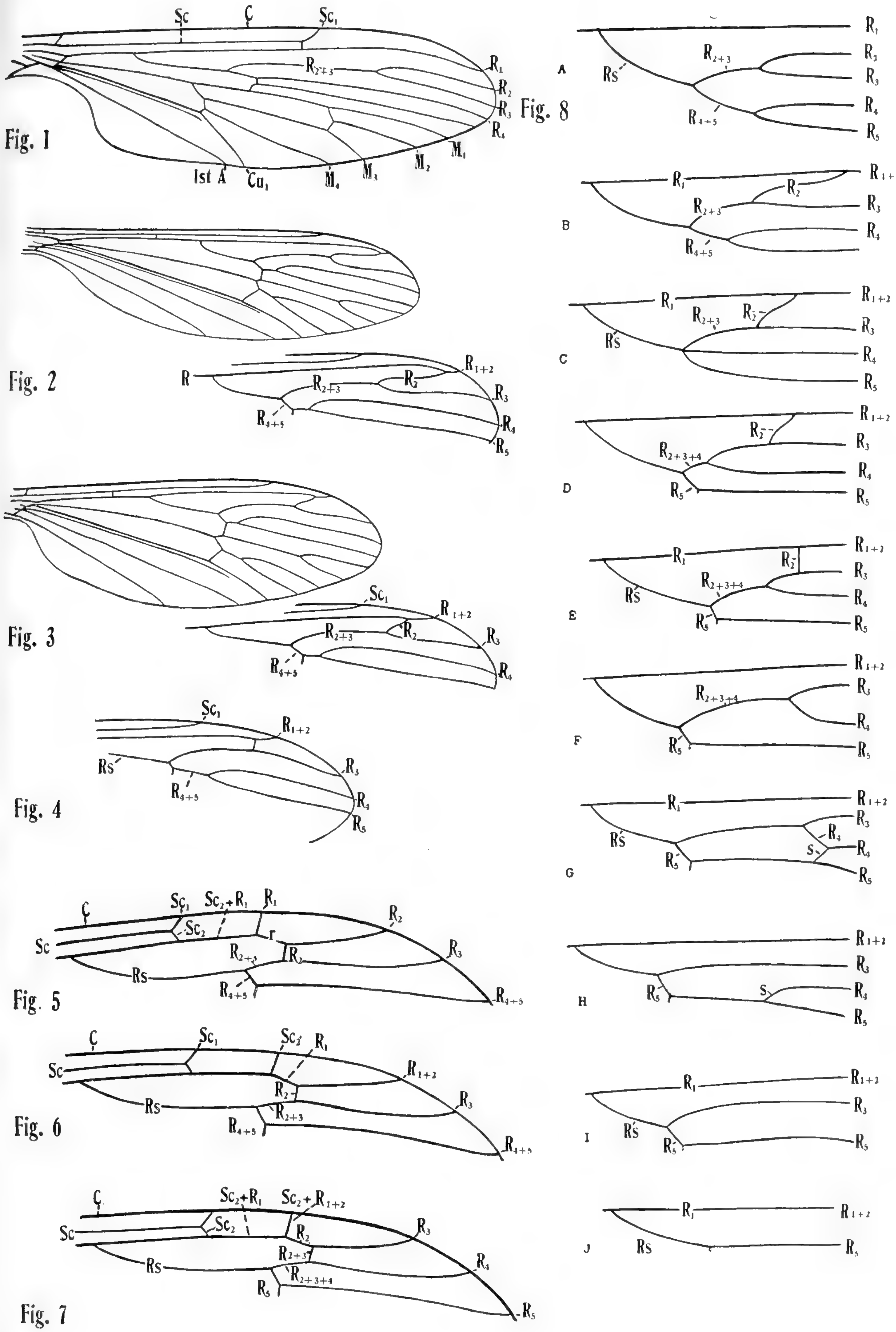
Fig. 5

ALEXANDER (1927)

(MEDIAL AND CUBITAL FIELDS — TILLYARD - 1918)

s = supernumerary x-vein

Alexander, Radial Field of the Wing in the Diptera.



Alexander, Radial Field of the Wing in the Diptera.

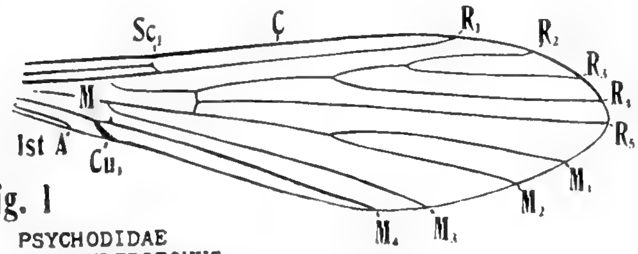


Fig. 1
PSYCHODIDAE
PHLEBOTOMUS

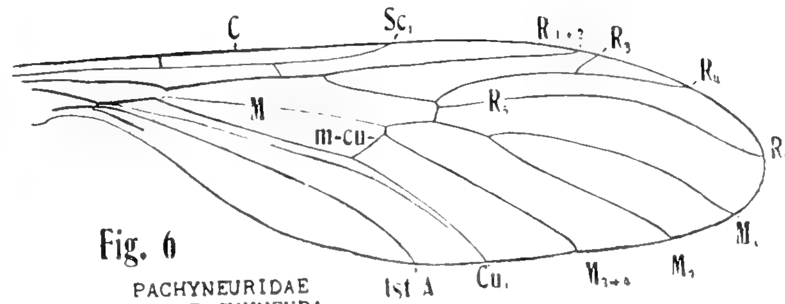


Fig. 6
PACHYNEURIDAE
PACHYNEURA

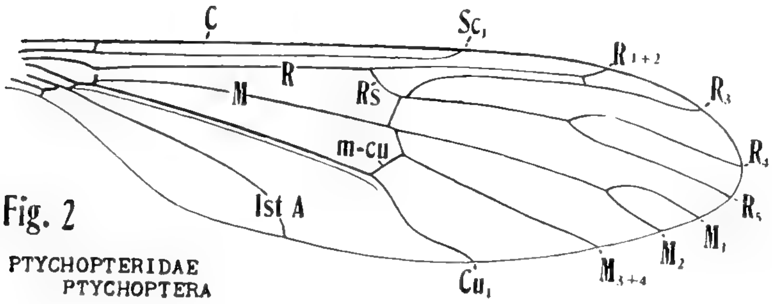


Fig. 2
PTYCHOPTERIDAE
PTYCHOPTERA

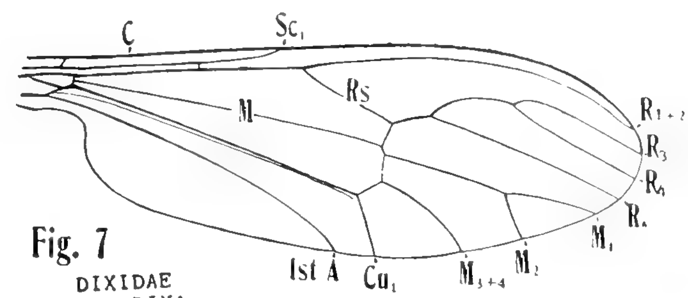


Fig. 7
DIXIDAE
DIXA

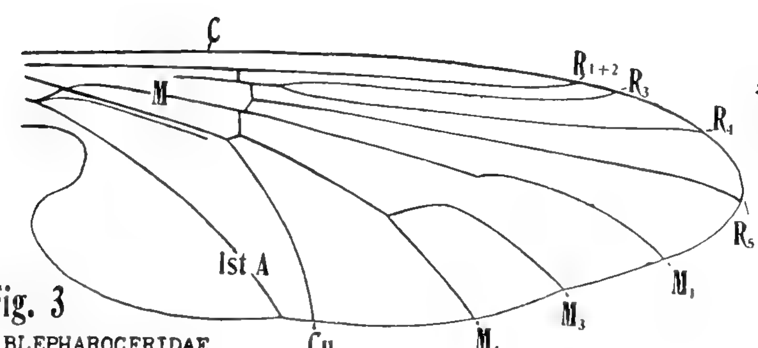


Fig. 3
BLEPHAROCERIDAE
EDWARDSINA

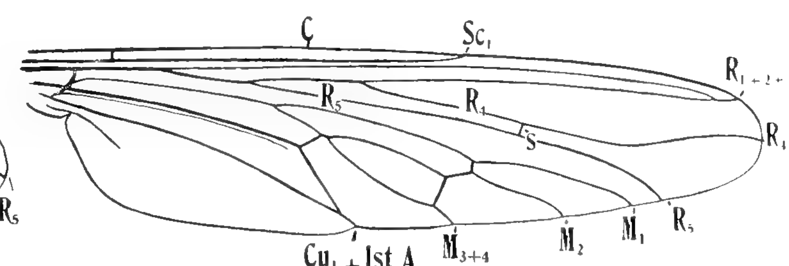


Fig. 8
ASILIDAE
PROMACHUS

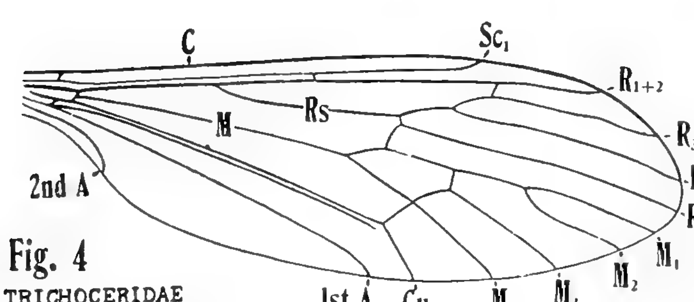


Fig. 4
TRICHOCERIDAE
TRICHOCERA

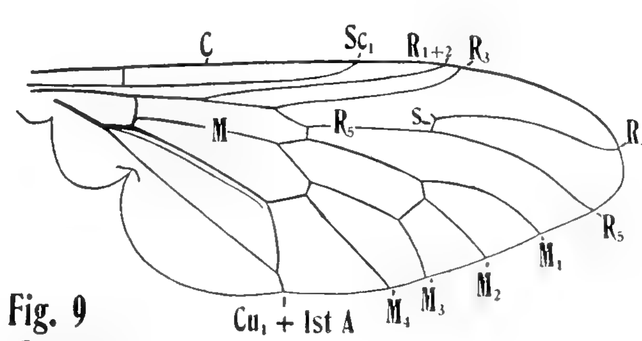


Fig. 9
LEPTIDAE
CHRYSOPILA

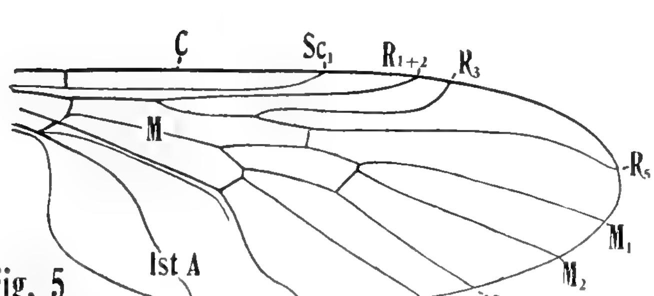


Fig. 5
ANISOPODIDAE
ANISOPUS

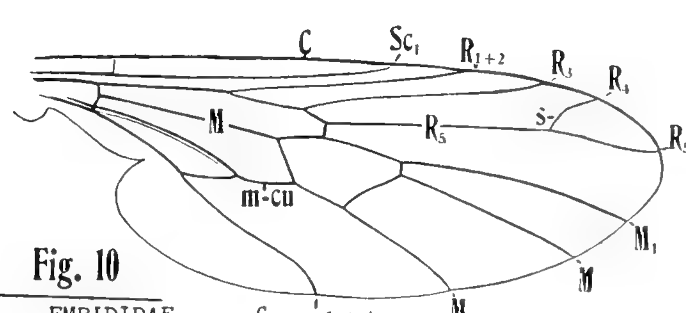


Fig. 10
EMPIDIDAE
EMPIS

Alexander, Radial Field of the Wing in the Diptera.

6. The same, as interpreted by Tillyard, Mackerras and Tonnoir *(in litt.)* (1927).
7. The same, as interpreted by Hendel *(in litt.)* (1928).
8. Diagrammatic series of figures, A to J, to show reduction of the Radius in the Diptera.

PLATE III.

Fig. 1. Wing of *Phlebotomus*, sp. *(Psychodidae)*.
2. Wing of *Ptychoptera rufocincta* O. S. *(Ptychopteridae)*.
3. Wing of *Edwardsina chilensis* Alexander *(Blepharoceridae)*.
4. Wing of *Trichocera salmani* Alexander *(Trichoceridae)*.
5. Wing of *Anisopus brevis* (Walker) *(Anisopodidae)*.
6. Wing of *Pachyneura fasciata* Zetterstedt *(Pachyneuridae)*.
7. Wing of *Dixa campbelli* Alexander *(Dixidae)*.
8. Wing of *Promachus bastardii* Macquart *(Asilidae)*.
9. Wing of *Chrysopila*, sp. *(Leptidae)*.
10. Wing of *Empis*, sp. *(Empididae)*.

Anopheline Mosquito Investigations in California.

William B. Herms, Professor of Parasitology, University of California, Berkeley.

Although Praslow (17), a German physician and traveller who visited California in 1857, found malaria well established at that time, stating that whole tribes of California Indians were wiped out by the disease, it is quite probable that it had been recently introduced by the white man. There appears to be a complete lack of mention of malaria in records of the Spanish missions in California. These missions were located along the coast in localities which are now and no doubt were then non-malarious, thus making it unlikely that the disease was introduced into California by the Spaniards. That malaria may have been introduced into this state prior to the great gold rush in 1849 is possible, since Cleland (4) states that Lieutenant Emmons and his party entering California in 1841 from Oregon, prior to his entrance into the Sacramento Valley were harassed by sickness, chiefly malaria. He arrived at Sutter's Fort (Sacramento) on October 17, 1841. In his journey down the Sacramento, the endemic anophelines might easily have become infected and the disease thus transmitted to the Indians.

Praslow's (loc. cit.) description of "Intermittens" is of interest: "Am gewöhnlichsten hat das Fieber die Tertianform und diese Fälle sind verhältnismäßig diejenigen, die am schnellsten heilen. Die quotidiane Form ist im Ganzen selten, etwas häufiger findet man Quartan-Fieber. Während die leichteren Formen mit Tertian-Typhus das ganze Jahr hindurch in wechselnder Stärke vorkommen, treten die intensiveren und hartnäckigen Fälle im Juli, August und September auf." Since this description of the disease was prior to the discovery of the causal agent, Praslow's account is, of course, based on clinical observations, the paroxysms. His reference to a stubborn and pernicious form of the fever, which he had also encountered on the Isthmus of Panama, is evidence to the effect that aestivo-autumnal malaria had already become endemic in California. It is quite probable that this form of the disease was introduced by gold seekers who came via the Isthmus of Panama, where many waited long for ships to carry them up the coast.

Malaria infected gold seekers working up the smaller valleys from the great interior valley and toward the Sierra foothills in 1849—1850 spread malaria as they went, creating new centers of infection, as no doubt was also done in 1856 by imported laborers, Italians in this case, in the building of the Sacramento Valley Railroad *) running from Sacramento to

*) Malaria is an old resident of California: *State of California, Dept. of Public Health, Weekly Bulletin,* Vol. VII, No. 20, June 23, 1928.

Folsom and the transcontinental railroad (5) in 1869—1870. The introduction of irrigation had much to do with the spread of malaria. Frontier newspapers, such as the "Placer Press" in 1858, stated that "Everybody west of Gold Hill is down with fever or chills or more or less affected by miasmatic poison floating about those regions," and the "Butte Record" of Oroville reported a "meeting of the townspeople to see what is to be done about the sickness afflicting nine-tenths of the people." Whether or not anything was done about it at the time is not recorded, but it is interesting to note that the editor of the "Oroville Register" in the issue of March 14, 1911 (more than fifty years later), voices a similar sentiment, viz.: "How goodly a city would we have if this one fault could not be laid against us: Like the ostrich who hides his head in the sand and thinks the whole body is concealed, we here may say there is no malaria. But we deceive no one but ourselves.... It is up to you! What are you going to do about it?" On the evening prior to the appearance of this editorial an illustrated lecture had been given by the writer in the Superior Court room at Oroville on mosquitoes and malaria, a complete report of the same appearing in the "Register" with bold headlines, "Anti-malaria Campaign Started Last Night at Rousing and Enthusiastic Meeting; Court Room Crowded to the Doors; Much Interest Manifested."

My first contact with the malaria problem in California came while attached to the speakers staff of the Agricultural and Horticultural Demonstration Train which operated throughout the state during the winter and spring of 1908—09. My own little demonstration consisted of four small glass-covered boxes containing specimens of fleas, lice, flies, ticks and particularly specimens of anopheline mosquitoes, and a few charts. My short talks on "Medical Entomology" elicited questions concerning mosquitoes and malaria only in certain parts of the state and I soon found that a real malaria problem existed particularly in several northern California counties. The first real evident desire for assistance came from Penryn, Placer County, in a letter dated December 22, 1909: "We here in the Placer foothill region want to fight the malaria mosquito, but do not know how to proceed.... Can we not expect some aid in this.....?" On Feb. 12, 1910 a permanent "anti-malaria-mosquito organization" was formed. This we believe to have been the beginning of the first organized civic campaign against malaria in the United States. A complete account of this project was published by the writer in 1913 (10) together with an account of the Oroville campaign the start of which has already been alluded to. Other communities quickly followed the lead of Penryn and Oroville, notably Bakerfield in Kern County, and Los Molinos in Tehama County. Each of these enterprises was financed by local committees through subscriptions, entertainments, tag-days, and the like. It should be stated here that although the Penryn campaign was the first mosquito campaign directed specifically against anophelines, there had been organized previously a very successful campaign against certain salt marsh species, as reported by Quayle (19) in 1906. In all of this early mosquito control work, the chief obstacle was the uncertainty of financial support. This was largely corrected by the enactment of assembly bill No. 1565 (passed in 1915), "An act to provide for the formation, government, operation and dissolution of mosquito abatement districts in any part of the state, to

facilitate the extermination of mosquitoes, flies and other insects; and to provide for the assessment, levy, collection and disbursement of taxes therein." Under this act eighteen districts, twelve of which are directly anti-malarial in objective are now in operation.

With work begun in four counties, namely Placer, Butte, Tehama, and Kern, the need of a general statewide malaria-mosquito survey became more and more obvious. The following resolution was adopted by the State Board of Health, March 4, 1916, "That the State Board of Health undertake, in cooperation with the University of California, a survey of malaria and mosquitoes in California under the direction of Professor W. B. Herms, assisted by Mr. S. B. Freeborn, provided the funds of the Board will permit of the financing of the plan."

The survey as proposed was carried out by the writer and a small group of assistants, the work having been done during the summer months of 1916, 1917 and 1919, the world war taking our interest during 1918. We covered approximately 20,000 miles by automobile, visiting every county in the state, reaching elevations ranging from about two hundred feet below sea level in the Imperial Valley to about ten thousand feet above sea level in Tuolumme County. The highest elevation at which endemic malaria was encountered was 5480 feet in Sierra County.

Many thousands of mosquitoes were collected and breeding places noted, hundreds of copies of State Board of Health Special Bulletin No. 9 (Malaria and Mosquito Control, by the writer) were distributed, numerous lectures were given, great numbers of personal visits were made to farms and advice given to farmers, health officers and others. A card index of all localities visited was prepared, each card showing species of anophelines taken, occurrence of malaria, data concerning mosquito breeding places, recommendations made, and so forth. A map of the state showing by means of colored pins the distribution of anopheline mosquitoes was also prepared.

Anopheline mosquitoes were taken in all but the following California counties, viz.: Alpine, Del Norte, Imperial, Inyo, and Mono, and it is possible that a more intensive search might reveal them in one or more of these, notably Imperial and Inyo. These anophelines are of three species, namely, *Anopheles maculipennis* Meigen, *Anopheles punctipennis* Say, and *Anopheles pseudopunctipennis* Theob., of which the latter, although not occurring in such numbers as *A. maculipennis,* is most general in its occurrence.

The survey showed that malaria was not a widespread disease in California, but where it did occur it was at least equally if not more than twice as prevalent as in the more malarial states of the South. Our badly infected area is about half the size of Mississippi, and the disease was at the time of the survey more than twice as prevalent as it was in that state.

It may be of interest to note that Placer County, in which the first anti-anopheline mosquito operations occurred, had a malaria death rate in 1909 of 27.7 per 100,000 population, reduced to zero in 1927, and Butte County, in which the second campaign was begun, had in the same year (1909) a malaria death rate of 64.3 per 100,000, standing at 3.1 for 1927. The state as a whole suffered a death rate of only 4.9 per 100,000 for 1909 this rate for the state as a whole being reduced to 0.35 per 100,000 for 1927

(see Table I) with enormous reductions in all the originally more seriously affected counties as suggested above for Placer and Butte counties. Much of this has been accomplished by the slow process of educating the masses in the matter of mosquitoes and malaria as well as sanitation in general. No doubt the improvement of sanitary conditions in general in many of the smaller communities had a highly beneficial effect.

TABLE I.

Showing malaria death rates for California per 100,000 population for the years 1909 to 1927, inclusive.

Year	Population	Deaths	Death Rate
1909	2,305,020	112	4.9
1910	2,396,639	113	4.7
1911	2,488,256	121	4.9
1912	2,579,874	101	3.9
1913	2,671,491	77	2.9
1914	2,763,109	70	2.5
1915	2,854,727	45	1.6
1916	2,946,347	54	1.8
1917	3,037,968	47	1.5
1918	3,129,789	55	1.8
1919	3,372,819	28	0.8
1920	3,480,903	34	1.0
1921	3,588,977	43	1.2
1922	3,697,081	31	0.8
1923	3,805,155	32	0.8
1924	3,913,239	24	0.6
1925	4,021,323	29	0.7
1926	4,129,406	9	0.22
1927	4,237,490	15	0.35

Quayle (loc. cit.), in connection with his survey of mosquitoes in the immediate vicinity of San Francisco Bay, reported *Anopheles maculipennis* Meig. both near Burlingame (San Mateo County) and San Rafael (Marin County). Although endemic malaria probably never existed in either of the above localities, the writer (10) early recognized that this was "for California the most dangerous species". Some confusion, however, soon arose as to the identity of the species, hence in papers dealing with this anopheline in California both the terms *Anopheles quadrimaculatus* Say (16) and *Anopheles occidentalis* D. & K. (13) are used. A general account of this species both as to synonymy and habits is to be found in "The Mosquitoes of California" by my associate, Professor Freeborn (1926), and an earlier reference by the same (8) to the overlapping of *A. maculipennis* and *A. quadrimaculatus*.

Distribution of Anophelines in California.

In the mosquito survey of California above alluded to and officially reported (11 and 12), 573 collections of mosquitoes were made, totaling 6389 mosquitoes of all kinds of which thirty-six per cent were anophelines (18.5 % *A. maculipennis*, 4 % *A. punctipennis*, and 13.5 % *A. pseudo-punctipennis*).

A. maculipennis Meig. occurs in nearly all parts of the state (text-fig. 1) except the true desert areas and the high Sierra, although the warm

valleys which have an easterly exposure to the Nevada plateau have been invaded (Freeborn), note the focus at Sierraville, Plumas County, at an elevation of 5480 feet.

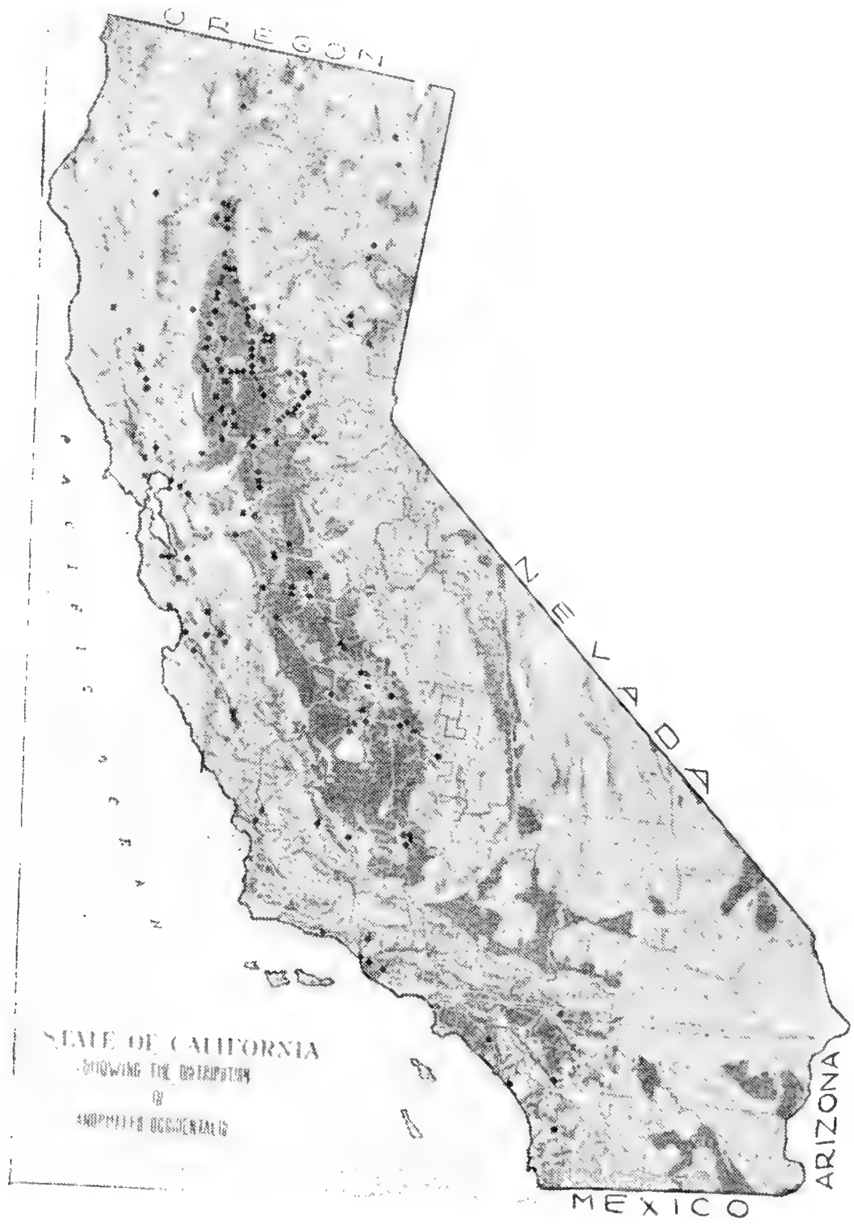


Fig. 1. — Distribution of *A. maculipennis* in California.

Anopheles punctipennis Say is the predominating anopheline in the Sierra foothill sections (text-fig. 2), occurring in greatest numbers along the Mother Lode, and is abundant in certain limited areas along the Sacramento River where breeding places are offered in wooded situations. The species appears to be rare south of the Tehachapi mountains.

Anopheles pseudopunctipennis Theob. is the most widespread anopheline south of the Tehachapi (text-fig. 3) and thence extends northward along the coast to Sonoma and into the great central valleys to the northern end of the Sacramento, reaching into the Sierra foothills of the San Joaquin. We have recently reared this species at Coachella (Riverside County) from larvae taken at a point about 175 feet below sea level.

Seasonal Distribution.

The writer has been bitten by *Anopheles maculipennis* in the field as early as the first few days in January and thereafter on warm, sunny days, a common experience throughout the following six or eight weeks. With remarkable regularity year after year about February 20, there is a great dispersal flight of this species. For a period of ten to fourteen

days following this date these mosquitoes (only females) invade communities throughout the great valley of California, invading houses and biting viciously even in bright sunlight. Many districts are invaded that are many miles from breeding places and entirely free from *Anopheles* during the remainder of the year. With the flight ended, the mosquitoes rapidly disappear and are practically absent in April. During this flight eggs are laid and in due course of time first brood adult mosquitoes appear (males and females) reaching a peak (see Fig. 4) early in June, when there is again a rapid falling off of individuals. From the eggs deposited by this, the second, brood, there results the third (second for males) and highest peak in September.

Fig. 2. — Distribution of *A. punctipennis* in California.

Beginning in June 1919, Freeborn (7) began making weekly collections of *Anopheles maculipennis* at a given point (a highway bridge) near Chico, continuing thus through into August when the collections were made by W. C. Purdy of the United States Public Health Service who sent all mosquitoes to our laboratories for identification, continuing to do this so that in all about sixteen consecutive months were covered in the project. In all 26,010 mosquitoes were collected and identified of which 5,756 were *Anopheles maculipennis.* The results of this study are shown in text-fig. 4, and described above. Unfortunately we have no such comprehensive obser-

vation to report for our other two species of anophelines except that at no time have we observed a spring dispersal flight for either.

Although a number of workers, among them Griffiths (9), Barber, Komp and Hayne (2), and Balfour (1), have reported immature stages of anophelines during the winter months we have as yet failed to find either larvae or pupae during November, December and January in the Sacramento Valley where our species, particularly *Anopheles maculipennis*, are abundant. The mean minimum temperature for the three months, November, December, and January, at Davis in the Sacramento Valley (Univerity of California Farm) was 37.3° F (2.9° C) for a five year period, the average lowest recorded for same period 26.9° F (— 2.9° C), and the average warmest 65.7° F (18.7° C).

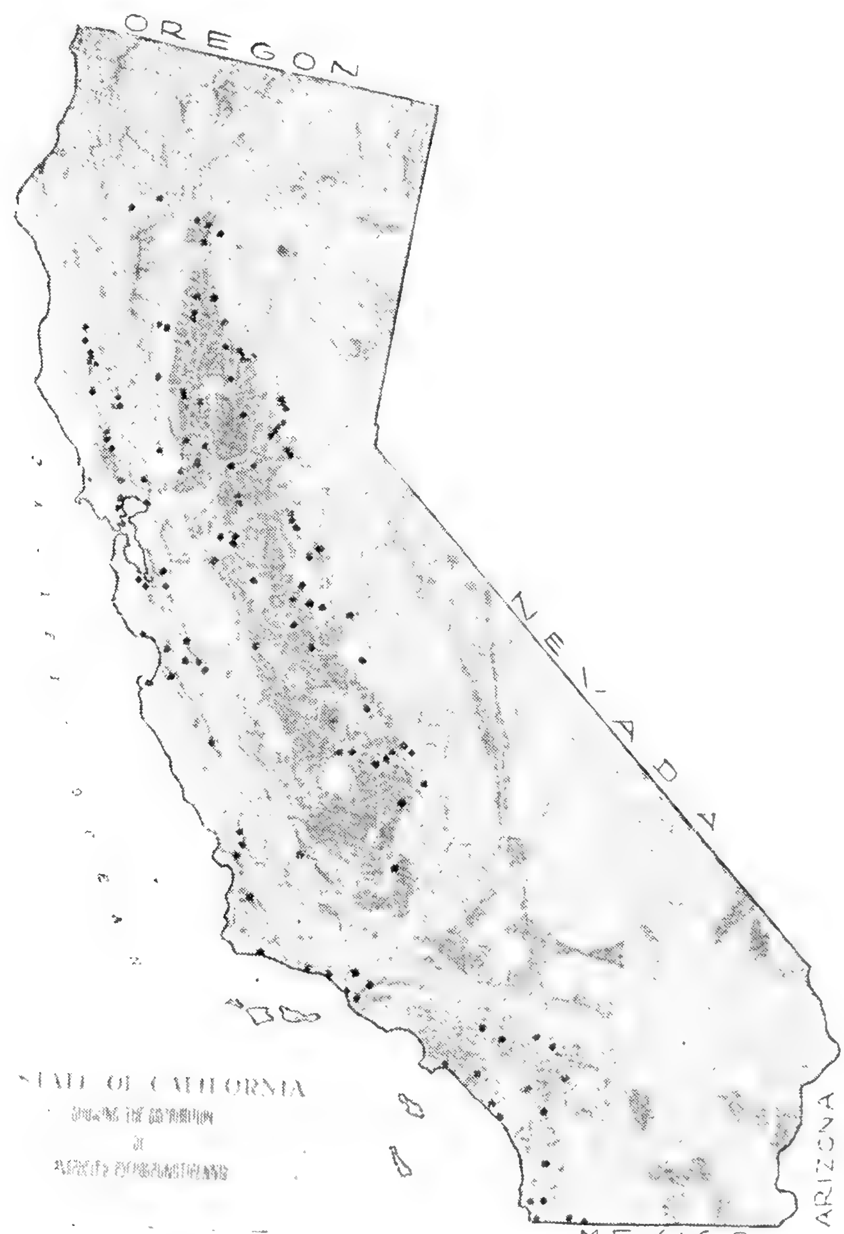


Fig. 3. — Distribution of *A. pseudopunctipennis* in California.

Use of Gambusia in Anopheline control.

The top minnow, *Gambusia affinis*, was introduced into California from Texas by the California State Board of Health during the summer of 1922 and distributed to various parts of the state for mosquito control. In many instances remarkable results have been achieved, but in most cases this tiny fish has had to contend with conditions more or less adverse to its existence. As is well known the dry season of California results in a gradual complete drying up of many of the smaller streams or a reduction

to a series of stagnant pools many of which are prolific in anophelines. Then follow the heavy rains during the rainy season and all Gambusia which might have found a haven in or had been introduced into the left-over pools are often washed out, thus necessitating a renewal during the following early summer (15). Dredger ponds et cetera which had been stocked with minnows during the spring dried up during the summer and were not re-stocked during the following summer. The clever little Gambusias were widely advertised as the panacea for all our mosquito ills (a substitute for the more laborious methods of mosquito control had long been sought), a sort of over confidence was built up with the result that in some instances, at least, an actual increase in malaria incidence resulted.

Nevertheless when properly administered we do have in this splendid little top minnow a potent enemy of mosquito larvae. Last summer (1927), while checking up on some work done at Anderson, Shasta County, where the state had conducted a demonstration malaria control district (6) in 1919 and the Gambusia had been later introduced, we found great numbers of these minnows carrying on effectively in neglected weed and grass grown ditches in spite of very difficult conditions.

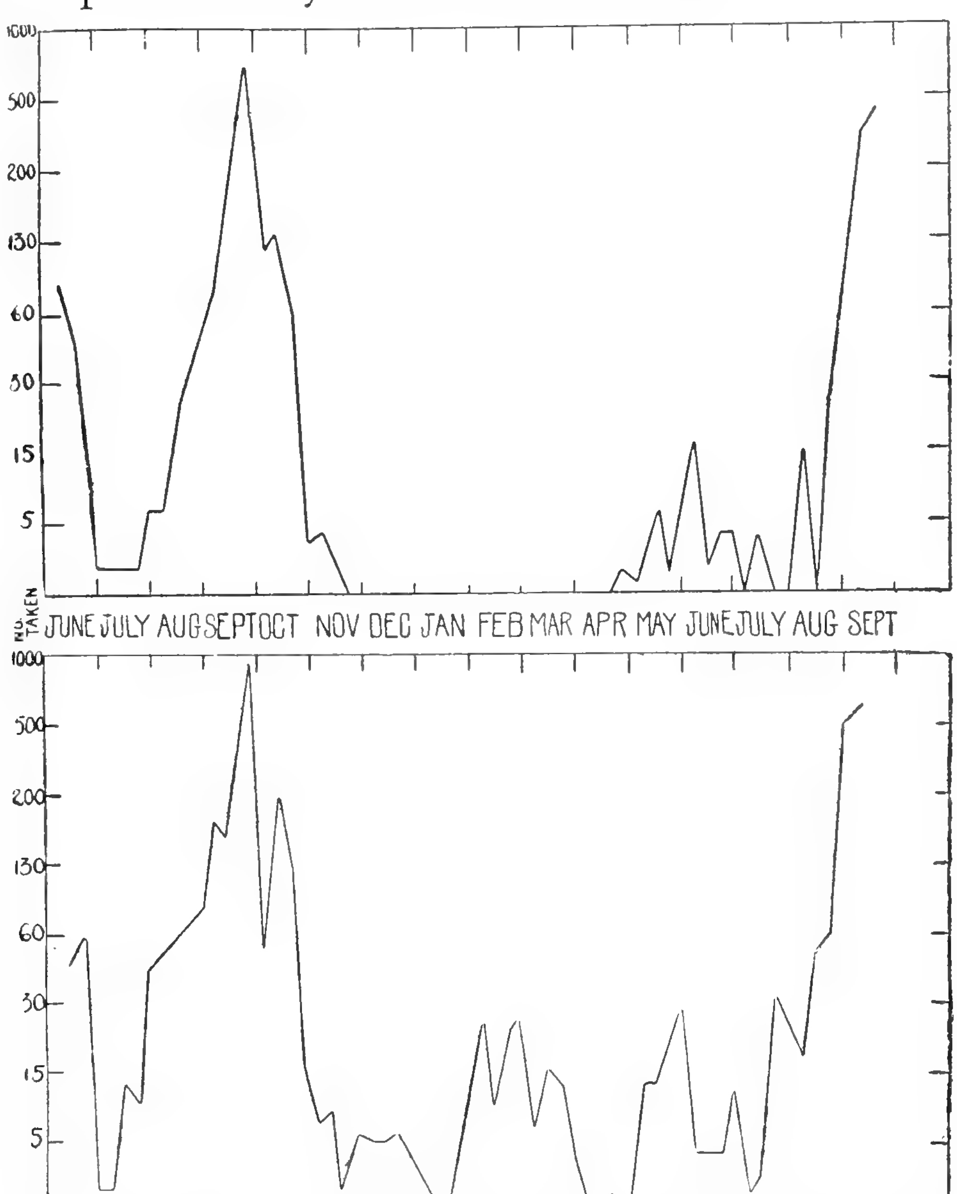


Fig. 4. — Showing the relative seasonal abundance of males and females of *Anopheles maculipennis* taken in the Sacramento Valley near Chico, California. (After Freeborn.)

Anophelines and Rice Culture.

With the introduction of rice culture on a commercial basis in California in 1912, and its rapid expansion in less than five years to about 70,000 acres in the Sacramento Valley alone, and that in a malarious

locality, there was some concern as to the health hazard. It was soon found that not all rice fields were productive of anophelines; indeed, in many of the original fields no anophelines were to be found, while other and newer fields to the northward showed greater or lesser numbers apparently increasing in general toward the upper end of the Sacramento Valley. This is well shown by the work of Purdy (18) who studied larval production in four rice fields during the rice growing season of 1920, making weekly examinations which showed the following averages for the season: field No. 1 (Nelson), one-fifth per examination (only two larvae taken here during the whole season); field No. 2 (Durham), two miles distant, northerly, twenty-six; for field No. 3 (Nord), twenty miles northerly, seven and one-half; field No. 4 (Anderson), seventy-five miles northerly, thirty-three. The culicine production in field No. 1 was also very low, namely 2, the other three fields showed also a relatively high culicine production, viz.: field No. 2, an average of 11; field No. 3, an average of 26; and field No. 4, an average of 20.

The lack of breeding in the Nelson rice field (field No. 1) during 1919 and 1920 was the object of much careful study on the part of Purdy, who concludes, ".....a careful comparison of the Nelson field (field No. 1) with all other fields and puddles seems to indicate no considerable or essential difference in (1) number of larval enemies; (2) relative amount of food supply; (3) temperature; (4) alkalinity of the water; (5) free CO_2; (6) dissolved oxygen; (7) relative stability, ... however, study of the alga growths does reveal a difference which appears to be as fundamental and as well marked as is the contrast in breeding. The Nelson field contains a very heavy growth of a blue-green alga *(Tolypothrix tenuis)* which is not found except in rare instances and in very minute quantities, in any of the other fields or waters examined."

No doubt the porosity of the soil at Anderson (field No. 4), which required constant replenishment of water, thus keeping it relatively fresh, had much to do with the abundance of anophelines at that point, in contrast with the so-called hard-pan conditions where most of the rice is grown. Rice growing has been practically abandoned as unprofitable in the neighhorhood of Anderson, where it did form a health hazard of some consequence. Seepage pools, particularly road-side seepage from rice fields, will always need to be considered as a menace.

Yeast as a Suitable Food.

Although we have for a good many years been able to rear anophelines in small numbers in the laboratory for experimental purposes, the percentage of imagines emerging has always remained very low, i. e. less than five per cent and the factors under which the mosquitoes were reared have always remained largely unknown. While carrying on experiments during 1924 in relation to the factors influencing growth of mosquito larvae (unpublished notes), we learned that yeast could be used effectively as a food for certain species, lending itself admirably to *Theobaldia incidens* in particular. With four grams of yeast to a litre of distilled water (pH 6.6) as high as 96 % of our mosquitoes *(T. incidens)* were able to carry through to emergence (14).

Boyd (3) reports à high degree of success in rearing *Anopheles maculipennis* with the aid of yeast as food. His method of feeding consisted of daily rubbing Fleischmann's yeast into the superficial layer of the water in the culture pan. In our work we followed out the same plan used in rearing *Theobaldia incidens,* namely, adding at the beginning a given quantity of comminuted yeast to a litre of distilled water, battery jars being used as containers. The jars were previously autoclaved and kept well covered during the experiment with sheets of absorbent cotton between bobbinet (see text-fig. 5), entrance for purposes of pH readings being gained through a hole plugged with cotton. The pH readings were made with the aid of La Motte's color standards.

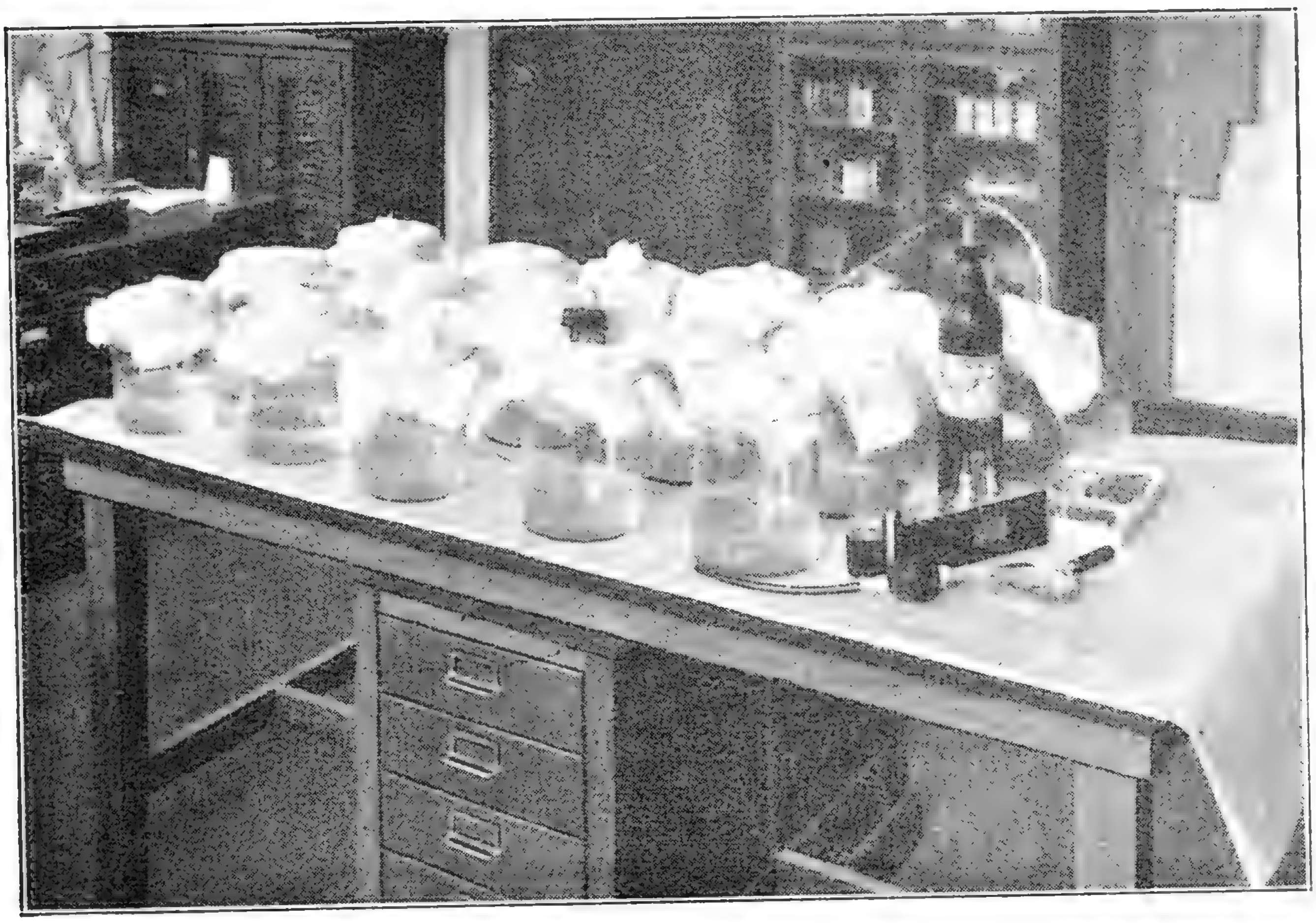


Fig. 5. — Showing laboratory set-up for experiments in relation to yeast as a food for mosquito larvae.

Female *A. maculipennis* were collected in the field, brought to the laboratory, and placed singly in bobbinet-covered wine glasses containing a small quantity of distilled water. Almost without exception eggs were deposited within forty-eight hours. The eggs from seven to eight females were transferred to a larger receptacle with distilled water and thoroughly mixed, then counted out in lots of seventy-five and placed in battery jars containing a known quantity of Fleischmann's yeast, i. e. 0.5, 1.0, 1.5, 2.0, 2.5, 3.0 and 4 grams to a jar. Preliminary experiments show that yeast can be used as the sole food for *Anopheles maculipennis* larvae, but so far we have not succeeded in securing better than a 10 % emergence, and that with three grams of yeast to a litre of distilled water. This investigation is being continued. Autoclaved and synthetic yeasts are giving interesting results.

pH of the water.

In a rapid survey in July 1927 of certain pools in the Sacramento Valley in which there were present the larvae of *Anopheles maculipennis*, pH readings were made in widely separated regions on both sides of the Sacramento River from near Sacramento to Redding. We made the following readings: 7.6, 7.6, 7.6, 8.0, 8.4, 7.3, 7.4, 7.5, 7.4, 7.5, 7.4, 7.8, 7.6, 7.6. Many other readings were made of pools in which culicine larvae were found and some pools in which there were no larvae of any species. In all of these the pH varied from 7.3 to 8.6.

In an effort to test the pH requirements of the medium a series of buffer solutions were prepared, battery jars with one litre of the solution and three grams of Fleischmann's yeast to a jar being used. The pH of the various jars was 5.4, 5.8, 6.2, 6.6, 7.0, 7.4, 7.8, 8.2, 8.4, 8.6, and 9.0. The yeast did not materially affect the pH. No success was had with this experiment, although a similar test with 250 cc. of buffer solution and 0.75 gram of yeast at a maintained temperature of $80^0 \pm 2^0$ F ($26.5^0 \pm 1^0$ C) gave some success at a pH of 7.0 to 7.6, the time required for the entire life history from egg deposition to emergence being twenty-two days. At room temperature with an average of $70^0 \pm 3^0$ F ($21^0 \pm 1.5^0$ C) with similar food conditions some success was had at a pH of 7.0 to 7.4. In checking over our experiments I find that in all successful emergences of *Anopheles maculipennis* in the laboratory no matter what the temperature or food conditions were, regardless of whether the pH at the beginning was 6.6 (the pH of our distilled water), the pH during the final days of the life history was above 7.0 (7.2 to 8.0). In spite of this fact it is the opinion of the author that the pH of the solution does not play an all important role in the development of the larvae of *A. maculipennis*, although perhaps more so than for *Theobaldia incidens* which tolerates a pH range of at least 5.4 to 7.6 in our experience.

Egg-laying Habits in Laboratory.

The Anophelines used for laboratory observations during the late summer of 1927 were collected *) under a bridge near Richvale (Butte County), California. The collections were made during the early afternoon hours when large numbers of mosquitoes were at rest under the bridge. At the time of the first collection, September 9, it was reported that about equal numbers of males and females were present, while for the second collection, September 23, there were about twice as many females as males, and at the time of the third collection, October 28, there were about ten females to one male, no larvae being observed in the marginal pools, many having been taken here on former visits. The mosquitoes collected on the last visit, October 28, showed no signs of a blood meal.

Of each lot collected a considerable number were placed seperately in small glass tumblers with distilled water and covered with bobbinet. No blood meal was offered these wild mosquitoes except in special cases by means of a capillary tube or ear of a rabbit. Of the lots collected on Sep-

*) The collections were made by Mr. J. F. Lamiman and Miss A. F. Downing, the latter being responsible also for many accurate observations relative to feeding and egg laying noted in this section.

tember 9 and September 23, seventy-eight laid eggs (temperature average about 70° F, 21° C). In nearly all cases the eggs were deposited during the second and third nights in captivity, although a few did not ovulate until the fifth or sixth day, the females invariably dying shortly after egg deposition, frequently the same night. In this manner many thousands of eggs became available for experimental purposes: about 20,000 eggs were used in our experiments during the autumn of 1927.

Although the females collected October 28 were treated in the same manner as those collected on previous occasions, i. e. under room temperature, together with many kept in a warm insectary at about 80° F (26.5° $\pm$ 1.5° C), ovulation did not occur except in a few cases where a blood meal was accepted. Obstinacy marked the behavior of most individuals of this, the winter brood, with respect to food. Out of fourteen females accepting food only two deposited eggs, thirteen and fifteen days elapsing between the first blood meal and egg deposition. As expected, larvae resulted from these eggs in the usual time, i. e. two and one-half to three day's incubation period, — temperature average about 70° F (21° $\pm$ 1.5° C).

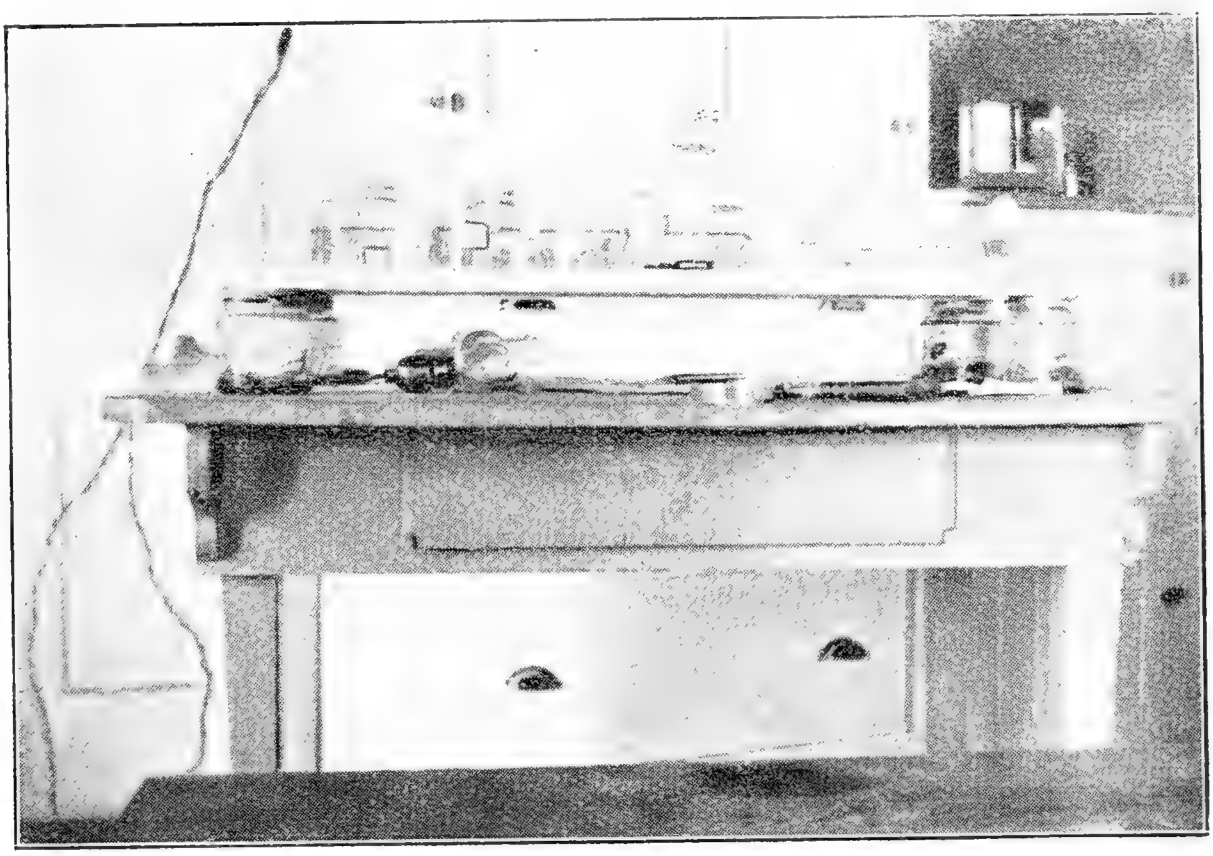


Fig. 6. — Showing laboratory set-up used in the study of the egg-laying habits of Anophelines. Jars containing mosquitoes are resting upon the glass of an elevated glass door, thus permitting the use of an incandescent lamp beneath.

The writer together with Freeborn has previously (16) reported observations relating to the number of eggs deposited by anophelines (see text-fig. 6). For *Anopheles maculipennis,* a total of 358 eggs in two layings of 218 and 140 was reported for one female. In this season's work (1927), this total is increased to 385, in two layings of 199 and 186 for the same species.

Sundry Investigations.

Compared with yeast as a food, laboratory studies indicate that a more rapid development and greater size of *A. maculipennis* is obtained

through the use of certain protozoa in pure culture, particularly a species of Bodo. A detailed study has been made for each larval instar of the development of the so-called palmate hairs and of the outer and inner anterior clypeal hairs, also the number of teeth of the lateral plate of the eighth segment. These studies were made in order to find a more satisfactory basis for the differentiation of species in the larval stage. Although not wholly satisfactory the "capillary tube" method of feeding was used by Miss Downing on our anophelines in the laboratory. The long palpi of the females seem to interfere with placing the tube over the beak of the unwilling mosquito. A rabbit's ear was much more satisfactory for the wild mosquitoes, as were our forearms for those bred in the laboratory. During the summer of 1920 (May 12-July 11) the stomachs and salivary glands were examined of 102 *A. maculipennis* and 132 *A. punctipennis* taken in our daily out-of-door collections in a malarial district (i. e. wild mosquitoes). All were negative for Plasmodium, indicating that wild mosquitoes are not as a rule dangerous.

Literature.

1. Balfour, Marshall C. — 1928. Studies on the bionomies of North American anophelines. Winter activities of anophelines in coastal North Carolina (36⁰ N. Lat.); in Amer. Jour. Hygiene 8 (1), pp. 68—76.
2. Barber, M. A., W. H. W. Komp and T. B. Hayne. — 1924. Some observations on the winter activities of Anopheles in southern United States; in U. S. Public Health Reports 39 (6), pp. 231—246. (Reprint No. 900, Feb. 8).
3. Boyd, M. F. — 1926. A note on the rearing of anopheline larvae; in Bul. Ent. Research 16 (IV), p. 308.
4. Cleland, R. A. — 1922. A History of California, American Period. The Macmillan Co., N. Y.
5. Ebright, Geo. E. — 1916. Report of the Committee on Malaria; in Trans. Commonwealth Club of California 11 (1), pp. 3—11.
6. Freeborn, S. B. — 1920. Malaria control. A report of demonstration studies at Anderson, California; in California State Board of Health Mthly. Bul. 15 (9), pp. 279—288.
7. Freeborn, S. B. — 1921. The seasonal history of Anopheles occidentalis D. & K. in California; in Journ. Econ. Ent. 14 (5), pp. 415—421.
8. id. — 1923. The range overlapping of Anopheles maculipennis Meig. and Anopheles quadrimaculatus Say; in Bul. Brooklyn Ent. Soc. 18 (5), pp. 157—158.
9. Griffiths, T. H. D. — 1918. Winter hibernation of Anopheles larvae; in U. S. Public Health Reports 33 (46), pp. 1996—1998, (Reprint No. 491, Nov. 15).
10. Herms, W. B. — 1913. Malaria, cause and control. The Macmillan Co., N. Y.. XI + 163 pp.
11. id. — 1919. Occurrence of malaria and anopheline mosquitoes in northern California; in U. S. Public Healgth Reports 34 (29), pp. 1579—1587 (July 18).
21. id. — 1920. Occurrence of malaria and anopheline mosquitoes in middle and southern California; ibid. 35 (6), pp. 275—281, (Feb. 6).
13. id. — 1921. Distributional and ecological notes on anopheline mosquitoes in California; in Journ. Econ. Ent. 14 (5), pp. 410—414.
14. id. — 1928. The effect of different quantities of food during the larval period on the sex ratio and size of Lucilia sericata Meig. and Theobaldia incidens Thom.; ibid. 21 (5), pp. 720—729.

15. id. — 1928. Limitations in the use of top minnows in Anopheles mosquito control in California and observations on anopheline flight activities; in Southern Medical Journ. 21 (9), pp. 761—762.

16. Herms, W. B. and S. B. Freeborn. — 1920. Egg-laying habits of California anophelines; in Journ. Parasit. 7 (2), pp. 69—79.

17. Praslow, J. — 1857. Der Staat California in Medicinisch-geographischer Hinsicht. Göttingen.

18. Purdy, W. C. — 1925. Biological investigation of California rice fields and attendant waters with reference to mosquito breeding; in U. S. Public Health Service Bul. 145, p. 61.

19. Quayle, H. J. — 1906. Mosquito control; in California Agr. Exp. Sta. Bul. 178, pp. 1—55.

Communication among Termites.

Alfred Edwards Emerson, Professor of Zoology,
University of Pittsburgh, Penna.

It has been said that speech is the greatest discovery of the human race in that it provides a mechanism for cooperation between individuals and consequently lies at the foundation of human society. Wherever it is necessary among the lower animals for two or more individuals to cooperate for the biological success of the species, we find the sense organs employed to make one individual aware of the presence of the other. The primitive association of the sexes is brought about in a variety of ways. Chemical stimuli seem to have developed first, but later touch, sight and hearing have been added to the means of sexual attraction. Sometimes one set of stimuli predominate over the others, but often a variety of stimuli may start the series of responses which lead to a given action.

When we come to examine the mechanism of communication among the highly socialized insects, the problem is more complicated because of the more complex types of cooperation. Although many interesting observations have been made from time to time, our knowledge of the systems of communication among termites has been rather limited until recently and I propose here to briefly outline some of the mechanisms which have been discovered.

It has long been known that odor plays an important part in holding a society of termites together. The individual termite possesses an odor which is recognized by other members of the termitarium. As in the case of the honey bee, an individual of the same species, but from a different colony, will immediately be recognized as a foreign invader and will often be attacked if it comes in contact with members of another colony. However, I once experimented with two colonies of *Nasutitermes banksi* in British Guiana and induced them to join by placing the nest particles and invaded wood of each colony in a mason jar. After several weeks the jar was examined and the two colonies were indistinguishable. The colony odor of each group had evidently been mixed through this forced association, and the individuals had learned to recognize the resultant odor as the right one to stimulate cooperation. This chemical response can best be seen along the trails of the termites where each individual follows the one in front through all the little devious curves of the course, no matter whether several feet of space may separate them.

The termite nest is not occupied alone by one species of animal. In many cases numbers of other forms, Collembola, Heteroptera, Diptera, Hymeoptera and Coleopetera as well as Acarina, are found living with the termites in the capacity of predators, scavengers and symbionts. It has

been said that these insects are attracted to the termitarium because of protection, constant relative humidity and temperature, lack of light, abundant food supply, etc. Probably all these factors are important, but the mechanism of this association seems to result largely from an odor response. A colony of *Nasutitermes costalis* was found in British Guiana migrating over the surface of the ground early one morning. The king and queen were in the middle of the procession together with a large number of soldiers and workers, but strangest of all, seven species of termitophiles were also found in the trail. These included a species of Collembolan, two mites and four species of beetles. Parasites, scavengers and symbionts were included. All of these termitophiles were responding to factors which were part of the migrating colony of termites and were facing hazardous conditions of light, temperature, moisture and shelter. A similar phenomenon occurs along the trails of migrating army ants (Eciton) in British Guiana. Thus it can be seen that the biotic factors are fully as important, if not dominant over the physical factors in the analysis of the ecology of these biocoenoses.

The sexes seem to be attracted largely through odor and chemical contact. After swarming forth from the nest, the female of *Coptotermes testaceus* was observed to shed her wings, raise her abdomen in the air and wait. After a short time, a male could be observed coming toward the female. The male could sense the female odor at least three feet away and would run toward her in an undulating course which seemed inconsistent with sight. As soon as the male touched the female, off she would go in search of a favorable nesting site with the male following in tandem. Sometimes the female started so quickly that the male was left behind. In this case the female would soon stop, raise her abdomen and wait until the male again found her.

Although taste and smell are difficult to distinguish among insects and may be impossible to separate as distinct senses, I think they had best be separated tentatively for the purpose of this discussion. Professor W. M. Wheeler has recently brought forth his theory of "Trophylaxis" which postulates an exchange of exudates as a basis of cooperation among certain social insects, notably the ants and termites. There seem to be no new observations upon the termites which tend to discredit Professor Wheeler's theory and, on the contrary, it is difficult to find any other mechanism involved in certain complicated actions in the social life of these insects. The queen, young individuals, soldiers, other workers and many species of termitophiles are licked and massaged, all in response to the production of fatty dermal exudates, while the eggs are surrounded by a liquid, when extruded from the abdomen of the queen, which is eagerly lapped up by the termites, thus contributing to the care bestowed upon the eggs by the workers.

The winged reproductive forms always possess well developed eyes, while the other reproductive castes and the sterile castes nearly always have reduced eyes or are totally blind. The majority of termites live in dark situations under the ground, in excavated wood or in nests where the sense of sight must be of little or no benefit. It is not surprising, therefore, to find no social cooperation dependent upon sight. The swarming termites change from a negative phototropic response to a positive response,

emerge from the nest and, soon after finding a mate, they revert to a distinct negative response and seek a dark spot to construct a cell which later is enlarged into the nest. This brief period, often only a few minutes in length, seems to be the only utility for the eyes of the imagos and as already pointed out, the eyes do not seem to function in finding a mate or in any other act involving a cooperative action with another member of the species.

Likewise few actions on the part of any termites have been observed which involved a touch stimulus unassociated with a chemical stimulus and the sense of touch has never been proved to be of any social benefit. Probably touch is the main stimulus bringing forth the defensive responses of the termites, but no one has suggested this sense as an important means of communication, as far as I am aware.

We next come to an examination of the sense of hearing among termites and it is this sense which has been engaging my attention during the last few months. Certain sounds have been heard from time to time and are recorded in termite literature. It is also well known that the termites possess so-called ears on the tibiae of the legs. The mechanisms by which these sounds have been produced, however, have not been clearly understood and also certain sound producing mechanisms which are desribed in the following paragraphs have been constantly referred to in the literature as adapted to other purposes.

In the first place, let us examine for a moment the response of the termite to sound. I once found a nest of *Nasutitermes guyanae* under construction. The termite soldiers and workers were on the outside of the nest and in a favorable location for experiment. I made every variety of noise that I could think of from high squeeks to loud hammering, and the termites made no response even when the noise making apparatus was within six inches of them. At the same time, however, I touched the nest very delicately and the excited response was very definite. They were able to detect a very slight vibration through the substratum of the nest, but they were unable to detect loud vibrations through the air. Every observation I have made upon these insects has verified this conclusion.

Let us now turn to the possible methods of sound production among termites. These methods have been observed by various students, but there seems to be great confusion concerning the mechanism concerned. A number of years ago I heard audible sounds produced by soldiers of *Armitermes percutiens* in British Guiana. These sounds were produced when the colony was disturbed, and thus probably are of use as a warning to the other members of the colony. The head is held in a horizontal position and is banged on the substratum at the rate of about three times a second. The sound is distinctly audible to human ears five or six feet away. Professor F. Silvestri has heard such sounds produced by soldiers of *Syntermes molestus*, *Cornitermes similis*, and *Armitermes euamignathus* and Mjöberg reports the soldiers of *Rhinotermes intermedius* making an audible noise among dry leaves by tapping the head.

I also detected a similar action on the part of the soldiers of *Leucotermes tenuis*. The termites had invaded some paper wrappings and were disturbed. I was surprised to hear a distinct whir like a miniature rattle

snake, and I soon found that the soldiers were vibrating their heads rapidly upon the paper on which they were standing. The head tapped the paper about ten times a second and the noise lasted about one second. I never detected any sound production on the part of this species in the field, and I believe the reason lies in the fact that the paper made a good sounding board, while the sound was lost to human ears on the wood in their natural surroundings.

A few months ago I decided to test these substratum vibrations more carefully and with the help of Mr. Robert C. Simpson, of the University of Pittsburgh, the following apparatus was constructed. The inside of a telephone transmitter, consisting of the carbon cup and screw to which the diaphragm is attached was joined to four dry batteries. The primary of a ten to one ratio audio transformer was connected to the microphone and batteries, while the secondary of the transformer was connected to the input terminals of an audio amplifier such as is used in radio work. An RCA Uni-Rectron AP-935 amplifier was used in this case, and an ordinary pair of head phones was connected to the output terminals of the amplifier. The diaphragm was removed from the telephone transmitter and a piece of the wood inhabited by the termites was threaded on the diaphragm screw.

The termites crawling upon the wood jarred the carbon grains, thus altering the current from the dry cells. This produced a sound which was amplified to the extent that a termite walking on the wood could be heard through the head phones. After several hours of observation, some soldiers of *Reticulitermes flavipes* on the wood were disturbed and were thus stimulated to hammer their heads upon the substratum. The noise was so great that it sounded unpleasantly loud through the ear phones. This action on the part of *Reticulitermes flavipes* has never before been recorded, and I imagine that the sound would be almost impossible to hear under natural conditions.

Thus it can be seen that termites in widely separated groups have the power to transmit substratum vibrations, and the experiments indicate that they only have the power to hear vibrations through the substratum.

There are other modifications which also seem to be connected with substratum communication. The gula of a number of termite soldiers is highly modified with ridges or humps, which may possibly be of use in connection with this tapping action. Also the curious snapping mandibles of several genera, notably *Mirotermes* and *Capritermes*, seem to be well adapted for the production of substratum vibrations. The mandibles are crossed and then snapped with such force as to cause distinct pain when they are held in the hand. If snapped against the side of a vial, the noise may be heard twenty feet away in the case of *Capritermes*. There is no doubt in my mind that this snapping action is an adjustment for substratum communication and not a means of defense as is so often stated in the literature. The force of the snap often causes the termite to jump an inch or so in the air and some students have thought that this was a method of retirement, but it seems probable that this jump is a secondary action and under normal conditions, within the nest, would be of little or no value. Professor Silvestri has suggested that this snapping action is a method of warning the colony, and I am strongly inclined to agree

with this hypothesis, because the other demonstrated means of substratum communication correlate so well with the known response of the termites to substratum vibrations. After tapping with a knife on a log containing *Mirotermes*, I was able distinctly to hear the snap of the soldiers' mandibles in response.

There still remains a curious action found universally among termites which also seems to be a method of communication. The termites will often be found jerking themselves back and forth rapidly while pivoting upon their legs. This action has been observed in the most primitive and the most specialized termites, and is found among all castes as well as among the young forms. Also it is significant that certain termitophiles also possess this remarkable habit. While testing the soldiers of *Reticulitermes flavipes* for the tapping action, I often observed the workers jerking themselves in the characteristic manner, but no substratum vibration could be heard through the delicate aparatus described. If this jerking action is a substratum communication, the vibrations are slower or of a decidedly different pitch than the tapping noise so easily detected.

That the jerking action is of use as a means of communication, however, seems amply demonstrated by the following observations. The termitophilous staphylinid, *Termitogaster emersoni*, was once observed to approach a worker of *Nasutitermes*, and the beetle jerked itself in the characteristic way of the termites. The worker immediately started to lick the beetle all over the body including the legs and antennae. When the worker stopped, the beetle again jerked itself and the worker again resumed the licking. The worker stopped twice while the pair was under observation and both times the beetle jerked itself and seemed thus to cause the termite to continue. This jerking is so often done without contact with another insect that touch is ruled out of the possibilities. Experiments must yet be performed to decide whether there is still an undetected vibration or whether there may be a mechanism involved which releases a chemical stimulant.

I think that I have been able to demonstrate that termite communication seems to depend largely if not entirely upon chemical senses and the detection of substratum vibrations. Any method devised by human beings to disrupt either system of communication would cause the disintegration of the social life of these insects. In this connection, Dr. T. E. Snyder has made the extremely interesting observation that buildings in southern United States occupied by constantly vibrating cotton machinery do not seem to be infected by termites and that untreated railway crossties in well-balasted roadbeds where there is heavy and frequent traffic also seem to be immune from termite attack. It thus seems probable that such outside vibrations may disrupt the communication system of the termites by producing a condition analagous to the static of the radio.

Discussion:

N. A. Kemner: As regards the curious mandibles of the *Capritermes*-soldiers I have quite another opinion than my friend Dr. Emerson. It seems to me impossible to believe that the *Capritermes*-soldier could have obtained its very big head with the curious mandibles only for the purpose of

making a warning noise to the other castes in the nest. In Java the *Capritermes*-termites live in the soft earth where a blow in the galleries would cause a very feeble sound. As I have pointed out in a paper read at the Xth Int. Zool. Congress at Budapest 1927 I believe that the curious distorted mandibles of these soldiers are a higly developed apparatus adapted for dealing out strong blows to enemies entering the narrow galleries in the ground. The sound which can then be heard is not caused by the blow on the soft earth, but by the small basic tooth on each mandible, these teeth striking one another when the mandibles are crossing each other.

The curious jumping of the *Capritermes*-soldier, which many observers have thought to be their real manner of escaping their enemies, is, in my opinion, only a strong recoil when the mandibles strike the ground instead of the enemy. In the narrow galleries, where under normal circumstances the *Capritermes*-soldiers are living, jumping is of course impossible and therefore only takes place when the soldiers are placed on the surface of the ground where the circumstances are entirely unnatural.

Some recently proposed Stomach Insecticides, a Review of the Patent Literature.

R. C. Roark, Insecticide Division, Bureau of Chemistry and Soils,
U. S. Dept. of Agriculture, Washington. D. C.

The purpose of this paper is to stimulate research by calling to the attention of entomologists those classes of materials which seem to offer the greatest promise as stomach insecticides. After brief mention of some compounds of arsenic, fluorine, thallium, and a few organic compounds, a list of mothproofing materials which have been patented in recent years is given. Nearly all these mothproofing materials are stomach poisons and are properly included in a paper on stomach insecticides.

1. Arsenic.

At present arsenic is the most extensively used and most dependable stomach insecticide. The average annual production of the principal arsenical insecticides in the United States is: Paris green, 5,000,000 pounds; lead arsenate, 25,000,000 pounds; and calcium arsenate, 30,000,000 pounds.

In order to overcome some of the disadvantages of the commonly used arsenical compounds, new arsenical insecticides have recently been announced. Thus, for example, brown-colored manganese arsenate has been proposed in place of lead arsenate for use on tobacco, because the residue of white lead arsenate upon dried and cured tobacco leaves produces the appearance of mold, thereby reducing the selling price of the tobacco (U. S. Patent 1,580,200 *)).

Processes of manufacturing manganese arsenate are described in U. S. Patents 1,574,118; 1,591,795; 1,648,577; 1,648,595; and 1,648,596.

Many improved processes of manufacturing calcium arsenate have been patented in recent years (U. S. Patents 1,532,577; 1,532,578; 1,544,250; 1,545,873; 1,562,490; and 1,626,872).

---

*) Copies of any patent can be obtained for: United States, 10 cents, sent to the Patent Office, Washington, D. C.; British, 1s. (plus postage, usually ½ d, outside the Kingdom), sent by Postal or Post-Office Order, payable to the Comptroller-General, the Patent Office, 25 Southampton Buildings, London, W. C. 2; French, 5 francs plus postage, sent to L'Imprimérie Nationale, 27 rue de la Convention, Paris (15), France. German patents can be obtained from the Reichspatentamt, Berlin; and Austrian from Verlag im Österreichischen Patentamt, I, Stubenring 1, Wien. Of Canadian patents only manuscript copies are obtainable. They are furnished by the Commissioner of Patents, Ottawa. Estimates of cost can be obtained in advance.

Photostat copies of foreign patents can be obtained for a small fee by application to the U. S. Patent Office.

The Department of Agriculture assumes no responsibility for the merits or workableness of any of the patents, nor does it recommend any of the inventions mentioned in this paper.

Probably the most interesting development in calcium arsenate is that of a specially prepared compound containing 20% arsenic pentoxide instead of the usual 40%. Walker (J. Econ. Ent. 21, p. 165, 1928) prepares this by heating arsenic trioxide with precipitated chalk in the presence of excess air at 650° C for from 15 to 60 minutes.

Improved processes of manufacturing lead arsenate continue to receive the attention of inventors (U. S. Patents 1,529,998; 1,564,093; 1,573,375; and 1,588,691).

A mixture of equal parts of soap bark and dextrine to be added to lead arsenate (or other insecticides) to improve its suspension, and spreading and sticking qualities is claimed in U. S. Patent 1,598,269.

Casein plus tannin (U. S. Patent 1,604,774) and tannin alone (Reissue 16,331) are used for the same purpose.

Lomanitz (U. S. Patent 1,584,235) claims an insecticide consisting of 72.5 % sulphur, 15 % lead arsenate, 10 % soluble resinous soap, and 2.5 % aluminium sulphate. The function of the aluminium sulphate is to form an insoluble sticker soap.

Colloidal white arsenic is patented for use as a rodent poison in U. S. Patent 1,636,776.

Elemental arsenic as an insecticide is patented in U. S. Patent 1,553,112 and British Patent 248,975, and the arsenide-sulphides and arsenides of iron, nickel, and cobalt are claimed in U. S. Patents 1,524,882 and 1,524,883.

New organic-arsenic insecticides are described in U. S. Patent 1,652,291. These include any organic trivalent arsenic compound normally solid and capable of being sublimed without loss of toxicity. Examples are: phenarsazine chloride, $(C_6H_4)_2NHAsCl$; phenarsazine oxide (diphenylamino arsenious oxide); triphenarsazine chloride, $(C_6H_4)_6N_3HAs_3Cl$; triphenarsazine oxide; methyl dichloroarsine, CH_3AsCl_2; methyl arsenious oxide, CH_3AsO; diphenyl chloroarsine $(C_6H_5)_2AsCl$; and diphenyl arsenious oxide, $[(C_6H_5)_2As]_2O$.

2. Fluorine.

Much interest has been shown in fluorine compounds during the past five years.

Processes of manufacturing fluorine insecticides are described in U. S. Patents 1,578,520; 1,578,521; 1,578,522; 1,578,523; 1,581,819; 1,617,708; 1,620,208; 1,634,122; and 1,648,143.

The principal objection to the sodium fluosilicate now commercially obtainable is its high apparent density or, as it is usually termed, few cubic inches per pound. Walker (J. Econ. Ent. 21, p. 156, 1928) has prepared a special light sodium fluosilicate containing not less than 80% sodium fluosilicate, which has the same density as calcium arsenate used for dusting cotton.

3. Thallium.

Fr. Bayer & Co. (British Patent 247,249) has patented a poison for rats, mice, sparrows, and other vermin, which contains thallium compounds, for example, thallous and thallic chlorides. It is stated that these are free from the bitter taste of strychnine. Thallium sulphate is the active

substance of "Zeliokörner" and "Zeliopaste", put out by Fr. Bayer & Co. for use against rats and mice (Bodnar and Terenyi, Z. anal. Chem. 69, p. 29, 1926).

4. Synthetic Organic Compounds.

Thiocarbanilide (symmetrical diphenyl thiourea), $(C_6H_5NH)_2CS$, is stated to be an effective stomach poison and also to repel insects. It is dusted upon plants, either alone or mixed with sulphur in the proportion of 15 to 85 (U. S. Patent 1,573,490).

5. Derris.

The root of *Derris elliptica,* which acts both as a contact and a stomach insecticide, has been examined in recent years by Takei in Japan. He calls the active principle "rotenone". This is a white crystalline substance with a melting point of 163.5° C, soluble in alcohol and ether, insoluble in water. The empirical formula appears to be $C_{23}H_{22}O_6$, but the constitution of rotenone has not yet been determined (Ber. 61, 1003, May 1928).

Processes of preparing Derris extracts have been patented as follows: U. S. Patents 1,522,041; 1,583,681; British Patents 3,204 of 1911; 10,215 of 1911; 8,322 of 1912; 226,250; 229,773; 233,857; 239,483; 246,252; 247,140; and 280,256.

6. Mothproofing Materials.

Within recent years a great variety of materials, organic and inorganic, have been patented for use in mothproofing woolen goods. Although some of these substances are stated to be repellents, the fact that many of them, for example, fluorine compounds, are odorless and are known to be stomach poisons for other insects, logically points to their inclusion as stomach insecticides. The writer has compiled the following table from recent patents on mothproofing compositions. Additional materials which were tested and found ineffective are recorded by Jackson and Wassell (Ind. Eng. Chem. 19, p. 1177, 1927).

Acridine. — Sulphonic and carboxylic derivatives of acridine are claimed for mothproofing purposes in German Patent 344,266.

Alkaloids. — Alkaloids from *Lupinus* (especially *L. albus, angustifolium, luteus, niger,* and *perennis)* seeds are claimed for mothproofing purposes in U. S. Patent 1,610,167. Cinchona alkaloids are claimed for mothproofing purposes by Jackson and Wassell (U. S. Patent 1,615,843 and Brit. Patent 263,092). See also Löwenstein (Austrian Patent 99,430) for use of quinine.

Amines. — Halogenated acylalkylamines are claimed for mothproofing purposes in German Patent 419,464.

Aminophenol sulphonic acids. — These derivatives are claimed for mothproofing in German Patent 344,266.

Anthracene — Sulphonic and carboxylic derivatives of anthracene are claimed for mothproofing purposes in German Patent 344,266.

Antimonic acid. — H_3SbO_4, is one of the materials claimed by Bayer & Co. (British Patent 173,536) for mothproofing wool. For example, 100 parts of wool is steeped over night in a bath consisting of 3 parts antimonic acid dissolved in 2 parts hydrofluoric acid, 3 parts concentrated sulphuric acid, and 3 parts alum. The wool is then rinsed and dried.

Antimoniotungstic acid. — $3H_2O \cdot 3Sb_2O_5 \cdot 4WO_3 \cdot 8H_2O$, is claimed by Bayer & Co. (British Patent 173,536) for mothproofing wool.

Antimony alginate. — Naefe (British Patent 160,039; German Patent 304,506) claims a method of protecting woolen fabrics from moths which consists in impregnating the cloth with a soluble salt of alginic acid, and then placing it in a bath of antimony salt.

Antimony potassium tartrate (tartar emetic). — Blancke (German Patent 430,186) mothproofs wool by soaking it in a solution of tannic acid and then in a solution of tartar emetic. Naefe (U. S. Patent 1,480,289) dissolves tartar emetic in alcohol and adds it to a solution of tannin in 70% alcohol in order to prepare a mothproofing solution.

Antimony salts. — The use of antimony salts in mothproofing woolen goods is described in the following patents: British Patent 160,039 and German Patents 304,506; 347,849; and 430,186.

Antimony tannate. — According to the process of Blancke (German Patent 430,186) antimony tannate is precipitated on the woolen fibers by dipping the wool in a solution of tannic acid and then in a solution of tartar emetic. Naefe mothproofs by applying an alcoholic solution of antimony tannate (British Patent 160,039 and U. S. Patent 1,480,289).

Benzil is one of the materials claimed for mothproofing in German Patent 346,597.

Benzilic acid is one of the materials claimed for mothproofing in German Patent 346,596. For example, 5 parts benzilic acid dissolved in 100 parts amyl-alcohol is used to moisten goods to be protected.

Benzoic acid derivatives. — The following derivatives of benzoic acid are claimed for mothproofing in Canadian Patent 280,549: 1-hydroxy-4-chloro-2-benzoic acid; 1-hydroxy-4 : 6-dichloro-2-benzoic acid; 1-hydroxy-6-methyl-4-bromo-2-benzoic acid; 1-hydroxy-4 : 6-dimethyl-2-benzoic acid; sulphurized 1-hydroxy-2-benzoic acid; sulphurized 1-hydroxy-4-methyl-2-benzoic acid; and derivatives and condensation products of said acids.

Benzoin is one of the mothproofing materials claimed in German Patent 346,597.

Benzophenone. — Sulphonic and carboxylic acid derivatives of benzophenone are claimed for mothproofing purposes in German Patent 344,266.

Benzylidenephenylhydrazone. — Derivatives of this compound are claimed for mothproofing purposes by Bayer & Co. (British Patent 238,287).

Benzylidenephenylmethyl hydrazone sulphonic acid is one of the compounds claimed for mothproofing purposes in U. S. Patent 1,562,510.

Bismuth nitrate, basic, $BiONO_3H_2O$, is one of the ingredients of the mothproofing composition claimed by Seynaeve (French Patent 545,930).

Carbazole. — Sulphonic and carboxylic acid derivatives of carbazole are claimed for mothproofing purposes in German Patent 344,266. Acetyl carbazole is claimed for mothproofing wool by Bayer & Co. (British Patent 238,287). Acetyl dichlorocarbazole is claimed for mothproofing wool in French Patent 581,037; British Patent 238,287; and U. S. Patent 1,562,510. Benzoyl carbazole is one of the materials claimed for mothproofing purposes by Bayer & Co. (British Patent 238,287). 3,6-Dichlorocarbazole is one of the materials claimed for mothproofing by Bayer & Co. (British Patent 238,287).

Cerium salts. — Kendall (British Patent 247,242) claims a process for mothproofing materials by impregnating them with cerium compounds the acid radical of which is a higher organic acid. The following cerium salts are mentioned: ricinoleate, resinate, stearate, oleate, linoleate, and tungate. Jackson and Wassell (Ind. Eng. Chem. 19, 1177, 1927) report cerium oleate to be ineffective for mothproofing.

Chaulmoogric acid. — Rare earth salts (cerium, lanthanum, didymium, thorium, zirconium, uranium, titanium and thallium) of chaulmoogric acid are claimed for mothproofing by Kendall (British Patent 247,242).

Chromium salts. — Bayer & Co. (German Patents 347,723 and 347,849) names chromium salts as metallic salts which may be added to a mothproofing solution, but states (British Patent 173,536) that chromium salts alone do not protect material from moths. Mullin (Textile Colorist 47, 162, 1925) states that chromium (salts) such as those used in dyeing do not appear seriously to impede cloths moth larvae.

Copper salts. — Salts of copper, according to Mullin (Textile Colorist 47, p. 162, 1925) are ineffective for mothproofing purposes. Copper salts of the halogen substituted phenols and cresols are effective for mothproofing fabrics and for protecting marine piling (U. S. Patent 1,085,783).

p-Cresotinic acid is one of the materials claimed for mothproofing by Bayer & Co. (German Patent 344,266).

Diazoaminobenzene is one of the compounds claimed for mothproofing by Bayer & Co. (U. S. Patent 1,562,510; French Patent 581,037; British Patent 238,287; and German Patent 402,341).

Dydimium salts. — Kendall (British Patent 247,242) claims the higher organic acid salts of didymium for mothproofing. The following salts are specified: ricinoleate, resinate, stearate, oleate, linoleate, and tungate.

Diphenylmethane. — The sulphonic and carboxylic acid derivatives of diphenylmethane are claimed for mothproofing purposes in German Patent 344,266.

Diphenyls. — Sulphonic and carboxylic acid derivatives of diphenyls are claimed for mothproofing purposes in German Patent 344,266.

Ditolyls. — Sulphonic and carboxylic acid derivatives of ditolyls are claimed for mothproofing purposes in German Patent 344,266.

Ethylidenephenylcarboxylic acid ethyl ester hydrazone is claimed for mothproofing purposes by Bayer & Co. (British Patent 238,287; French Patent 581,037; and U. S. Patent 1,562,510).

Ethylidenephenylhydazone is one of the materials claimed for mothproofing purposes by Bayer & Co. (British Patent 238,287 and German Patent 402,341).

Fluorides. Aluminium, ammonium, lithium, potassium, sodium, and zinc fluorides are claimed for mothproofing purposes in one or more of the following patents: U. S. Patents 1,085,783; 1,494,085; 1,515,182; 1,594,631; 1,634,790; 1,634,791; 1,634,792; British Patents 173,536; 235,914; 236,218; and German Patent 347,849.

Fluosilicates. — Aluminium, lithium, potassium, sodium, and zinc fluosilicates are claimed for mothproofing purposes in one or more of the following patents: U. S. Patents 1,634,790; 1,634,791; 1,634,793; 1,634,794; British Patent 235,914; 235,915.

Fluotitanic acid, H_2TiF_6. — This acid and its salts are claimed by Bayer & Co. (British Patent 173,536; German Patent 347,849) for mothproofing wool. For example, 100 parts of wool is placed over night in a bath (3,000 parts of water) containing one part of titanium hydrofluoric acid, H_2TiF_6, two parts of sulphate of zinc, 20 parts of Glauber's salt, and three parts of formic acid. The wool is then rinsed and dried.

alpha-Keto-dichlorotetrahydronaphthalene, according to German Patent 377,587, is suitable for use against moths and other pests.

I-Keto-monochlorotetrahydronaphthalene, according to German Patent 377,587, is suitable for use against moths and other pests.

Lanthanum salts. — Kendall (British Patent 247,242) claims the higher fatty acid salts of lanthanum for mothproofing. The following lanthanum salts are mentioned specifically: ricinoleate, resinate, stearate, oleate, linoleate, and tungate. Jackson and Wassell (Ind. Eng. Chem. 19, p. 1177, 1927) report lanthanum oleate to be ineffective for mothproofing.

Methyl violet crystals. — Wool dyed with methyl violet crystals was found to offer considerable resistance to clothes moth larvae and to black carpet beetle larvae, although by no means can it be called mothproof (Minaeff, Textile Colorist 49, p. 89, 1927).

Molybdic acip, $H_2M_0O_4$. — Bayer & Co. (British Patent 173,536) claims this material for mothproofing wool, furs. skins, and hair.

Naphthol yellow. — Tests in feeding clothes moth larvae with naphthol yellow (sodium salt of 2.4-dinitro-alpha-naphthol) are described by Mullin (Textile Colorist 47, p. 229, 1925). According to Clark and Craft (J. Soc. Dyers and Colourists, 41, p. 156, 1925), cloth dyed with martius (naphthol) yellow is completely mothproof.

Naphthylamine, acetyl is claimed for mothproofing wool in German Patent 346,597.

1-Naphthylamine-3. 6. 8-trisulphonic acid is claimed for mothproofing purposes in German Patent 344,266.

3-Nitroacetphenetidine is one of the compounds claimed for mothproofing purposes by Bayer & Co. (German Patent 346,597).

Nitrobenzene sulphonic acids are claimed for mothproofing purposes by Bayer & Co. (German Patent 344,266).

Nitro-p-toluic aeid. — Bayer & Co. mothproof 100 parts of wool with 1½ parts nitro-p-toluic acid, 1½ parts sulphuric acid, and 10 parts Glauber's salt (German Patent 344,266).

Pentachlorophenol. — Aylesworth (U. S. Patent 1,085,783) fireproofs and mothproofs fabrics by treating them with a solution of a higher halogenated substitution product of a carbocyclic compound, for example, pentachlorophenol. The fabric is first treated with a solution of the soda or potash salt of pentachlorophenol and is then treated with a solution of metallic salts, such as lead, zinc, calcium, barium, or aluminium, which yields a precipitate within the pores of the fabric. Perchloro-(hexachloro)-phenol is likewise employed.

Phenol sulphonic acids are claimed for mothproofing purposes in German Patent 344,266.

Phenolphthalein. — Wool treated with phenolphthalein shows considerable resistance to larvae attack (Minaeff, Textile Colorist 49, p. 90, 1927).

Phenyl acetic acid is one of the materials claimed for mothproofing purposes in German Patent 346,596.

Phenylhydrazide of dichlorophthalic acid is claimed for mothproofing purposes by Bayer & Co. (British Patent 238,287; French Patent 581,037).

Phenylmethylhydrazone benzylidene sulphonic acid is claimed for mothproofing purposes by Bayer & Co. (British Patent 238,287; French Patent 581,037).

Phosphomolybdic acid, $H_3PO_4 . 12MoO_3$, is one of the materials claimed by Bayer & Co. (British Patent 173,536) for mothproofing wool.

Phosphotungstic acid, $P_2O_5 . 12WO_3 . 42H_2O$, is one of the materials claimed by Bayer & Co. (British Patent 173,536; German Patent 347,849) for mothproofing wool.

Phthalic acid and its butyl, isobutyl, amyl, neutral, and acid esters are claimed for mothproofing purposes in German Patent 442,901. This patent also covers the use of halogenated phthalic acid and its esters, hydroxy phthalic acid, phthalic acid amide anhydride, and the methylamine and pyridine derivatives of phthalic acid. Aylesworth (U. S. Patent 1,085,783) fireproofs and mothproofs fabrics by treating them with a solution of a higher halogenated substitution product of a carbocyclic compound, for example, trichloro- and tetrachlorophthalic acids. The fabric is first treated with a solution of the soda or potash salt of these acids and is then treated with a solution of metallic salts, such as lead, zinc, calcium, barium, or aluminium, which will yield a precipitate within the pores of the fabric.

Phthalic acid bromimide is mentioned by Straub (German Patent 419,464) as being used against plant insects.

Phthalic acid phenylhydrazide is one of the materials claimed for mothproofing purposes by Bayer & Co. (British Patent 238,287; and German Patent 402,341).

Pyrazolone is claimed for mothproofing woolens by Bayer & Co. (U. S. Patent 1,562,510; British Patent 238,287; French Patent 581,037; and German Patent 402,341). bis-Nitrophenylmethyl pyrazolone chloride is one of the compounds claimed for mothproofing purposes by Bayer & Co. (British Patent 238,287; French Patent 581,037; U. S. Patent 1,562,510.

Quinoline. — Sulphonic and carboxylic acid derivatives of quinoline are claimed for mothproofing purposes in German Patent 344,266.

Stannic acid, H_2SnO_3, is one of the complex acids claimed by Bayer & Co. (British Patent 173,536) for mothproofing wool. For example, 100 parts of wool is boiled for one hour in a solution of 3 parts of colloidal stannic acid, after which the bath is acidified with 3 parts of concentrated sulphuric acid, and 10 parts of Glauber's salt is added. The wool thus treated is allowed to cool in the bath and is then rinsed and dried.

Stilbenes. — Sulphonic and carboxylic acid derivatives of the stibenes are claimed for mothproofing purposes in German Patent 344,266.

Sulphanilic acids. — These compounds as well as their alkylated and benzoylated derivatives are claimed for mothproofing purposes in German Patent 344,266.

Tetrachlorocresol. — Aylesworth (U. S. Patent 1,085,783) fireproofs and mothproofs fabrics by treating them with a solution of a higher halogenated substitution product of a carbocyclic compound, for example, tetrachlorocresol. The fabric is first treated with a solution of the soda or potash salt of tetrachlorocresol and is then treated with a solution of metallic salts, such as lead, zinc, calcium, barium, or aluminum, which will yield a precipitate within the pores of the fabric.

Tetrachlorophenol. — Aylesworth (U. S. Patent 1,085,783) employs this in the same way as tetrachlorocresol.

Thallium salts. — Kendall (British Patent 247,242) claims the thallium salts of the higher organic acids for mothproofing. The following thallium salts are specifically mentioned: ricinoleate, resinate, stearate, oleate, linoleate, and tungate.

Thorium salts. — Kendall (British Patent 247,242) claims the thorium salts of the higher organic acids for mothproofing. The following thorium salts are specifically mentioned: ricinoleate, resinate, stearate, oleate, linoleate, and tungate. Jackson and Wassell (Ind. Eng. Chem. 19, p. 1177, 1927) report thorium oleate to be ineffective for mothproofing.

Tin salts are used by Bayer & Co. (German Patent 347,849) in a mothproofing solution.

Titanium salts. — Kendall (British Patent 247,242) claims the titanium salts of the higher organic acids for mothproofing. The following titanium salts are specifically mentioned: ricinoleate, resinate, stearate, oleate, linoleate, and tungate. Titanium fluoride is one of the materials claimed by Bayer & Co. (British Patent 173,536) for mothproofing wool. Double fluorides of titanium, for example, ammonium double fluoride, are also claimed.

p-Toluene sulphodichloroamide is mentioned as a material for use against insects attacking plants (Straub, German Patent 419,464).

Trichloroethylacetanilide is one of the materials claimed by Straub German Patent 419,464) for mothproofing wool.

Triphenylguanidine is claimed for mothproofing purposes by Bayer & Co. (U. S. Patent 1,562,510; British Patent 238,287; French Patent 581,037; and German Patent 402,341).

Tungstic acid, $W_2O_5(OH)_2$, is one of the complex acids claimed by Bayer & Co. (British Patent 173,536) for mothproofing wool. For example, 100 parts of wool is heated to 100° C for an hour with a solution of 3 parts of colloidal tungstic acid in 3,000 parts of water, together with 20 parts of Glauber's salt and 5 parts of sulphuric acid. After being treated the wool is rinsed and dried.

Uranic acid, H_2UO_4, is one of the acids claimed by Bayer & Co. (British Patent 173,536) for mothproofing wool.

Uranium salts. — Kendall (British Patent 247,242) claims the uranium salts of the higher organic acids for mothproofing. The following uranium salts are specifically mentioned: recinoleate, resinate, stearate, oleate, linoleate, and tungate.

Victoria blue B. — Minaeff (Textile Colorist 49, p. 89, 1927) found that wool dyed with Victoria blue B showed considerable resistance to clothes moth larvae and black carpet beetle larvae, but by no means could be called mothproof.

Yttrium salts. — Kendall (British Patent 247,242) claims the yttrium salts of the higher organic acids for mothproofing.

Zirconium salts. — Kendall (British Patent 247,242) claims the zirconium salts of the higher organic acids for mothproofing. The following zirconium salts are specifically mentioned: ricinoleate, resinate, stearate, oleate, linoleate, and tungate.

The Development of Entomological Science in Egypt.

Hassan C. Efflatoun Bey, Director of Research,
Plant Protection Department, Ministry of Agriculture, Cairo.

The study of Egyptian hieroglyphics and papyri has revealed to us a great deal of the treasures of Ancient Egypt. The universe sees in these masterpieces the achievement of a standard of artistic workmanship which, at its best, has never been excelled. This incalculable inheritance of a magnificent civilisation eagerly searched for in our admiring epoch contains— alas! — but few traces of the existence of a science to which all here present are devoting their lives: I mean Entomology.

The meritorious publication by Rotter, Gough, v. Buttel-Reepen, Armbruster on „Die Biene in Ägypten jetzt und vor 5000 Jahren" is well known to most of us, and on the sarcophagus containing the mummified remains of Mykerinos (now in the British Museum and dating back 3633 years B. C.) is found a hieroglyphic bee representing the King of Lower Egypt. This indeed is a forcible illustration of the manner in which a colony of bees was recognised as the embodiment of government by a chief or ruler and it is in the earliest times of which there is any existing record. Another well-known Egyptian hieroglyph is that showing a dung beetle, *Scarabaeus sacer,* which lays its eggs in a ball of dung and may be seen compacting the pellet by pushing it backward with its hind legs. There can hardly be any doubt now as to what the Ancient Egyptians understood by this action: they compared the pellet to the globe of the sun. The Egyptian name was *Kheperer, Kheperi,* and the sign spelt the verb Khopi (r) meaning "become" and perhaps "create", also meaning "phenomenon" or "marvel". The insect was sacred to the sun-god in his form *Kheperi* at Heliopolis. Considering the life-history of the scarabaeus and its meaning as a hieroglyph it is now almost certain that the scarab impressed on a clay sealing had a symbolic significance.

Locusts and their ever dreaded and devastating invasions were by no means unknown to the inhabitants of Ancient Egypt. An excellent carving of a locust (in all probabilities *Schistocerca gregaria)* has been found on the walls of a tomb at Thebes and dating back to the period of Ramses, i. e. 1400 years B. C. Locust invasions (or plague as it was then called) is one of the seven plagues inflicted upon Egypt during the time of Moses, as narrated in the Old Testament, Exodus 10, 13—15:

"And Moses stretched forth his rod over the land of Egypt, and the Lord brought an east wind upon the land all that day and all *that* night; and when it was morning the east wind brought the locusts. And the locusts went up over all the land of Egypt: very grievous *were they;* before them there were no such locusts as they, neither after them shall be such.

For they covered the face of the whole earth, so that the land was darkened; and they did eat every herb of the land and all the fruit of the trees which the hail had left: and there remaineth not any green thing in the trees, or in the herbs of the fields, through all the land of Egypt."

This evidently is the first detailed reference on record to a great locust invasion. A most remarkable fact in the above reference is the direction of the wind, namely from the east, which is said to have brought the locusts, for it corresponds almost exactly with the east winds which were prevalent during all the locust invasions in Egypt of the last century. This, by the way, is an imporant element in the future study of bioclimatic conditions as affecting the means of dealing with insect pests.

Another equally interesting reference in the Old Testament is that contained in Exodus 8 relating to the plagues of frogs and lice and to the swarms of flies. The identity of the species of flies concerned is as yet somewhat doubtful, because we are not acquainted with any other reference describing any species of insects existing in or known to migrate into Egypt with a behaviour similar to "the swarms of flies" described in the Old Testament.

"Worms" (no doubt caterpillars of butterflies and moths and according to the opinions of several authorities these being no other than our present familiar cut-worm, *Agrotis ypsilon)* seem to have been mentioned on more than one of the ancient papyri. Two of these, in forms of letters, as stated by Sallier and Arasthasio, are said to contain the following curious paragraph: "The worm ate half the crop and the hippopotami ate the other half. The fields were full of rats, a swarm of locusts settled down and fed, the sheep also ate and the birds stole".

Another papyrus in hieroglyphics has been identified as being a royal decree where the director of the administration of agriculture reminds the farmers of the fact that "the worm" ate a large portion of the crop and that this was due to their negligence in dealing with it. Furthermore, he exhorts them to do their best that year to check it, kill it and thus reduce its harm.

Although it is not now part of the duties of the Plant Protection Section to deal with crop pests of the individual magnitude of the hippopotamus, nevertheless the smaller plagues, composed of less bulky creatures, compensate for their lack of size by the enormity of their appetite.

The revival of national activities was the work of the great Mohammed Aly Pacha (1805—1848), the genial inspirer and active organiser of the renewal of National spirit in Egypt. This undaunted reformer introduced into Egypt the cultivation of cotton, which found the fertile Nile soil most favourable for its remunerative development. Although the reign of Mohammed Aly was a reign of remarkable progress, yet the agricultural methods and customs which even then were sixty centuries old were subject to little if any alteration, and, in fact, one may say that they are the same even down to the present day. The need for an organized defence against the enemies of plants at that time made itself very little felt, for, to the Egyptian peasant and farmer, as well as to many of his western fellow-workers, an insect represented a manifestation of strength, which at one time was regarded as divine in origin and at another as of obscure origin, — but at all times badly defined and regarded as inevitable.

The science of entomology was in those days unknown in Egypt, and probably not wanted. It was indeed much neglected in the more advanced countries of Europe, where the activities of an entomologist were regarded by the mass of the people as nothing more than the dilettantism of an unoccupied, harmless and simple-minded man. It is only of recent years that signs have appeared that the entomologist is being appreciated at his true worth. Probably the study of Medical Entomology and the pioneer work of the U. S. A. in Agricultural Entomology have been the cause of this higher appreciation of Entomological science.

That period of profound ignorance of the value of science is definitely over for Egypt. The happy event of the accession to the throne of our august King Foad the First has opened an era of active enlightenment in all the domaine of the intellect and in that of science in particular. The generous support of this enlightened Patron has given a fresh impulse to very many scientific institutions which already existed in the country. The Agricultural Society, founded in 1898 by Sultan Hussein Kamel, received His Royal Patronage. It is to this Society that belongs the merit of having been the first to commend methods of protecting cotton, and it was this Society which took the initiative in the selection and distribution of cotton-seed. At that time this Society as well as the Higher School of Agriculture undertook advisory work in general agriculture before the actual existence of the Ministry of Agriculture.

The Entomological Society of Egypt, founded in 1907 by a small group of zealous entomologists and now placed under the august Patronage of His Majesty, has, owing to His Majesty's great benevolence and generosity, been able to reach a scientific standard worthy of the best entomological institutions in the World. Moreover, this fortunate support has enabled members of the Royal Entomological Society to take part in world-wide scientific collaboration. The Plant Protection Section (then called Entomological Section) of the Ministry of Agriculture came into existence in August 1911 by the appointment of one entomologist, who started work in technical research. In 1913 two more were appointed to work under the former, whose main duty was the establishment and classification of an entomological collection and the breeding of important economic insects. The next stage was the applications of the results of their studies to combating insect pests. Fumigation against scale insects was instituted; this operation soon assumed great importance through the efforts of the entomologists to improve its process. Measures were then taken to try to prevent the importation of disease from abroad, as had happened in the case of the Pink Bollworm, which pest, in spite of the attempts to eradicate it by the hot-air treatment of seeds, is far from being under control. The work of the Section grew rapidly in extent and a number of laws were promulgated. The basis of the work of the Plant Protection Section was defined and it was clearly pointed out that in order to ensure the development of the Section the entomologists should concentrate their efforts on research and when their studies reached the stage of formulating control measures against any particular pest, they should leave the application of these measures to other technical officials. This wise policy, however, was not found easy to follow, for, with the increase of administrative work, the director was hindered in continuing the im-

portant studies already commenced. Consequently it was found imperative to divide the Section into three divisions: one for entomological research, a second for mycological research and the third executive; the three to be independent of each other. When the first two bodies have achieved definite results in combating a pest, they pass them to the executive body for application, but when this latter faces any difficulties, it refers them for solution to the research bodies. The activities of the three bodies are under the direct control of one Chief Phytopathologist and are as follows:

1) and 2): Entomological and Mycological Research Sub-Sections. — Each of these has a director. They are assisted by Entomologists and Junior Entomologists, as well as Mycologists and Junior Mycologists respectively. Their duties comprise experiments, studies of life-history of insects and fungi, degree of spread and damage done by diseases, and remedies. They are also responsible for the publication of Bulletins, technical as well as popular, for the collection and classification of insects and the preparation of draft laws against plant diseases. In addition, part of the research work also comprises Sericulture and Apiculture. The breeding of useful parasites is not neglected although it has not been developed in Egypt to the same extent as it has been in other countries. The first attempt took place in 1890, when *Vidalia cardinalis* was introduced from California for combating the Fluted Scale *(Icerya purchasi)*, which threatened to ruin the orchards and ornamental gardens in Alexandria district. Its success was remarkable, for it is now well established everywhere in the country and is keeping this pest well under control. *Cryptolaemus montrouzieri* Muls. was introduced from France in 1922 with the original idea of combating the Sugar Cane Mealy Bug *(Pseudococcus sacchari* Ckll.). However, it was found more effective against the Hibiscus Mealy Bug *(Phenacoccus hirsutus* Green) and was propagated in great numbers and distributed in various parts of the country, where it did a fair amount of good. It seemed, however, to have encountered some unknown factor which hindered its natural progress. This problem is still receiving our careful attention, and we are hoping that in the near future we shall discover the causes which are preventing it of becoming the useful insect we had hoped it to be.

Recently information was received of a Braconid *(Microbracon kirkpatricki* Wilk.) which parasitized the Pink Bollworm in Kenya. In November of last year a member of our staff was commissioned to visit Kenya for the purpose of studying and collecting living specimens of this parasite. During his stay there he successfully shipped to us several consignments of this parasite, which, together with the quantity he brought with him on his return, gave us an excellent start. The seasons of Kenya do not coincide with ours, and this no doubt is the cause of the initial difficulty which we have experienced when endeavouring to breed this insect. It is possible that a second visit to Kenya will have to be made for obtaining a further supply of these parasites.

3) The Executive Sub-Section under a Director of Administration comprises:

(a) Fumigation Branch. — This branch undertakes the fumigation campaign, chiefly against the Black Scale, *Aspidiotus aonidum,* during the autumn and winter months and carries it out by the Pot

Method. Legislation authorizing the compulsory fumigation of infected gardens in districts in which infection has occurred was introduced in 1916. Several "arrêtés" were issued from that year until 1928 *re* the compulsory area which will have to be fumigated annually. The legislation also provides the necessary regulations to prevent the introduction of diseased fruit or plants into clean districts. During the season 1927-28, 4725 gardens containing over 1,000,000 trees were fumigated. The "Zyklon" gas and Calcium cyanide methods are still in experimental stages.

(b) Spraying and Dusting Branch. — Some sixty brigades are distributed in the country for the controlling of plant-diseases by spraying or dusting. All the work being done gratis, it is obvious that the Section cannot undertake to comply with all demands, hence preference is given to the controlling of plant diseases which are of the most economic importance. It is hoped that in the near future cultivators will gradually undertake the spraying and dusting of their crops under the guidance of the officials of the Section.

(c) Ginnery Control Branch. — Under a law of 1921 the entire bulk of cotton seed produced in all the ginneries in Egypt undergoes a compulsory treatment by hot-air. Samples of the treated seed are examined in the Section to ascertain the killing of the Pink Bollworm without damaging the germination capacity.

(d) Plant Quarantine Branch. — It carries out the laws and "Arrêtés" which have been issued with the object of safeguarding the country against the introduction of plant pests from abroad. Certificates of inspection or fumgiation, required by certain countries to which agricultural consignments are exported, are issued by the Section. This branch also controls the inland transport of certain agricultural consignments to guard against the spreading of the pests from infected areas or zones under disinfection to districts free from these pests. In some cases this transport is prohibited, or the consignments can be passed only after fumigation, which is carried out gratis.

(e) Finance and Administration (including Personnel, Stores and Workshops).

This short summary is mainly made up of statements devoid of originality owing to their being already widely known, and is intended mainly to draw attention to the scientific activity of young Egypt in regard to Entomology. The fauna of the New World is so absolutely different from that of Egypt that no extensive systematic relationship exists between the two countries. But if the species of insects in the two countries vary, methods of defence against them are nearly the same everywhere. The study of the Egyptian fauna is of outstanding interest owing to the distinctness of some three different faunas, i. e. (1) that of the Nile Valley, (2) that of the Eastern and Western deserts with the remarkable Oasis of the latter, (3) an almost distinct fauna found in a narrow belt along the Mediterranean Coast, which is mainly a prolongation of a similar belt found in Palestine and extends westwardly almost to Morocco.

In the future the possibilities for insect control in Egypt are great owing to the complete control of its water supply and to Egypt's peculiar climatic conditions. The most important of these conditions are that

(1) rain is almost completely absent, and

(2) the Nile Valley is hemmed in by a continuous desert area.

Further, the intense cultivation of the fertile region, and the immediate proximity of the desert leave hardly any room where a wild flora can flourish; hence its extreme poverty in species. A remarkable and interesting fact is that many insect pests of other countries are innocuous in Egypt, such as: the European Corn Borer *(Pyrausta nubilalis)* and the American Cotton Boll Worm *(Heliothis obsoleta)*.

I rejoice that my sejourn in U. S. A. will enable me to become acquainted with the best modern methods of control in their actual use. The study of the remarkable advance of American science, of its bold application to all branches of modern life, will, I trust, enable me to increase largely my modest stock of learning and enable me to place that new learning at the service of my country.

The Destruction of InJurious Insects before the Sowing Season of Sugar-beet.

Dr. Fr. G. Rambousek, Prague, Czechoslovakia.

Since many insects noxious to sugar-beet are found before sowing, it is quite natural that their occurrence should depend to a certain degree on climatic factors.

In this connection arthropods can be divided into two groups: 1) species which cause devastations only after long periods of from 10 to 20 years, and 2) others which are always present.

The most important arthropods of sugar-beet in Czechoslovakia are those which attack and soon destroy the young plants. They are in general *Julidae, Cassidae, Atomaria,* larvae of *Elateridae* and *Tenebrionidae*, as well as many others.

All these species can be captured early in the spring in pit-falls. Holes 20 cm broad and 10 to 15 cm deep are filled either with portions of sugar-beet (beet preserved for this special purpose) or with straw or rotten leaves. Carrots are especially suitable; they can be used as fodder for domestic animals after having been used to clean the fields.

The noxious insects are found only in certain spots of the fields. These places can be ascertained by holes dug at distances of 10 metres at points where bait has previously been placed. If in certain places a greater number of noxious insects are found, it is necessary to make here further holes at distances of 5 metres, most of the noxious larvae being attracted by the bait from a distance of 2½ metres.

The Elaterid larvae smell potatoes, sugar-beet or carrots at a distance of from 2 to 3 metres. This has been ascertained by experiments with larvae stained with anilin colours and placed at different distances from the pits. These pit-falls are prepared about 2 or 3 weeks before the sowing of the beet, and are dug out together with the surrounding soil after one week and given to domestic fowls, which will destroy the insects collected therein.

Naphthaline has proved a good repellent, valuable for the first period of growth. In consequence of the smell young plants are protected at least for 3 weeks. 5 to 8 kg of naphthaline are used for 100 kg of beet-seed. The price is only 15 to 25 cents per hectar. This is especially good for the control of *Atomaria.*

Now allow me to give some details of the noxious arthropods occurring in our country and of their control. *Julidae* are easily destroyed by pit-falls or later on trapped under moist canvas strips or small wooden strips. Besides, *Julidae* can be killed directly by pieces of sugar-beet poisoned

with barium chloride or natrium arsenate, which can also be used to destroy larvae living in the soil.

Silphidae hibernate as beetles and can be poisoned in the spring by spraying the leaves with a $^1/_2$—1 % solution of arsokol, or 6 % solution of barium chloride.

An *Atomaria linearis* attack can be forecast during the early floods in the spring, as the beetle can be found in the debris brought down by the waters. This species hibernates as adult. In consequence of the thawing of the snow in spring the water inundates the low-lying fields and brings with the debris a lot of insects. As they are carried by all rivers, this gives us a clear picture of the possible extension of damage caused by the insects in the spring. Being thus very exactly informed 2 or 3 months in advance of the future extension of *Atomaria,* we can prepare for adequate control of this pest. As the debris of the inundations contain, beside *Atomaria,* many *Elateridae* and other noxious insects, it is advisable to remove the deposit from the meadows and fields while it is still wet.

To control the *Elateridae,* the collecting of the beetles, in the debris in spring *(Agriotes obscurus)* or on flowers in summer *(Agriotes ustulatus),* seems to be one of the best methods.

The wild carrot *(Daucus carota)* may be used for this purpose, as its flowers are especially favoured by the *Elateridae.* For sowing the carrots, a sunny place near the fields should be selected, a strip 5 metres long and ½ metre broad. Extremely suitable for this purpose are infertile slopes protected from winds. It is quite important that the carrots should not be harvested, but on the contrary the patch should often be investigated during harvest time. This is the best time for collecting the *Elateridae,* as they are driven away from the meadows by the cutting of the hay and are now visiting the flowering carrots in greater numbers. For protecting sugar-beet from being destroyed by lice I propose to plant an *Evonymus* bush at each end of the carrot patch. The sugar-beet lice will hibernate only on the *Evonymus,* and so we have united the control of the plant-lice with that of the *Elateridae.* At the end of March or in April, the youngest branches of the *Evonymus* are cut off and burnt together with the collected fallen leaves. The Elaterid beetles can be collected on flowers from the second half of June till the end of July, the best results being obtained during sunny weather.

To control *Halticae* and *Cassidae* (both hibernating as adults) spraying with arsokol or dusting with calcium arsenate is advisable. *Halticae* are also easily caught in traps.

As to *Bothynoderes punctiventris* and *Melolontha,* I read a paper dealing with them at the Zoological Congress at Budapest. I shall here only add that by continually controlling the pests during the last five years and by the appearance of a parasitic fungus in 1926 the *Curculionidae* have now become very rare in the fields. Only *Otiorrhynchus ligustici* is more often found, since this beetle, which lives on different cultivated plants, is rather difficult to control.

To control caterpillars we usually employ arsokol, which I have recommended some 10 years ago; it adheres very well to the surface of the leaves and cannot be removed by the rain.

This year we had a serious outbreak of *Plusia gamma*, especially on fields of poppy, carrot and beet.

The leaf-miner *Pegomyia betae* Curt. is controlled by parasitic Hymenoptera, especially *Opius nitidulator* Nees. The outlook for the following year can be determined in the fall by the number of parasitised larvae. The reproduction of the parasites is to a great extend influenced by temperature, whereas the leaf-miner can develop very well at lower and higher temperatures. The larvae of these parasites can easily be reared from our common flies *(Lucilia, Musca, etc.)*. For this purpose decomposing meat or small dead animals are brought to the fields during cold weather in summer. This is done that the Hymenopterous parasites may easily find hosts in the maggots feeding on the dead animals and thereby be tided over until leaf-miner larvae are again available.

L'Entomologie Agricole et les Insectes Nuisibles aux Plantes de Culture en Bulgarie.

P. Tchorbadjief, chef de la Section Entomologique de la Station d'expérience et de contrôle, à Sofia, Bulgarie.

1. L'étude des insects en Bulgarie.

La situation politique, dans laquelle se trouvait la Bulgarie sous le joug turc, ainsi qu'il en était de tous les pays de la péninsule balkanique, depuis la seconde moitié du XVe siècle jusqu'à 1878, fut la cause de son détachement de la culture de l'Europe occidentale et de l'arrête en général de son développement culturel. En conséquence, l'étude des insectes en général et des insectes nuisibles en particulier restait fort en arrière. Les premières recherches sur la faune des insectes en Bulgarie ont commencé vers le milieu du XIXe siècle par des entomologistes étrangers. Des entomologistes bulgares ne se font remarquer qu' à peine vers le début du XXe siècle. De plus, il faut remarquer que toutes les recherches faites sous ce rapport, soit par des entomologistes étrangers, soit par des entomologistes nationaux, avaient un caractère zoogéographique et poursuivaient uniquement l'établissement et la caractérization des espèces rencontrées en Bulgarie; rien ne fut entrepris, en ce qui concerne les insectes nuisibles aux plantes de culture, jusqu'à la création de stations expérimentales d'agriculture (1902). Jusque là, il n'était question d'insectes nuisibles que fortuitement dans les cas où quelques espèces venaient à apparaître en masse et causaient des dégâts importants.

2. Les premières études sur les insectes nuisibles.

Avec l'ouverture des stations expérimentales d'agriculture, qui sont sous le ressort du ministère de l'Agriculture et des Domaines d'État, ont commencé aussi les premières recherches sur les insectes nuisibles. On a intallé des stations à Sadovo (près de la ville de Plovdiv) en 1902; à „Obrastzov-Tchiflik" (arrondissement de Russé) en 1905; et une Station centrale à Sofia en 1910. Celui qui contribua le plus à l'avancement de ces recherches fut incontestablement l'agronome phytopathologue feu K. Malkov (20—25), directeur de la station expérimentale d'agriculture à Sadovo, de 1902 à 1908 (année de sa mort). Dans les quelques comptes rendus, qu'il fit paraître, près de 200 espèces d'insectes nuisibles sont énumérées et la base de leur étude ultérieure fut établie. La direction que donne K. Malkov dans les recherches des insectes nuisibles fut suivie par ses continuateurs, notamment par K. Dospevski (6,7) directeur de la même station de Sadovo et par P. Kozarov (17—19), directeur de la station expérimentale d'agriculture à „Obrastzov-Tchiflik". Mais

plus tards, ces études tombèrent dans l'oubli et, depuis 1909 jusqu' à 1922 (inclusivement), les stations expérimentales d'agriculture ne publièrent aucun rapport compte-rendu qui contenait des renseignements sur les insectes nuisibles.

3. Le service relatif aux insectes nuisibles des stations expérimentales d'agriculture et la nécessité de son développement.

Bien qu'à la station de Sadovo, ainsi qu'à celle de Roussé (Obrastzov Tchiflik), l'étude des insectes nuisibles fût poursuivie pendant quelque temps, un service destiné à ces insectes n'existait pas encore. Ce n'est qu'en 1910—1911, avec l'ouverture de la station centrale d'expérimentation et de contrôle agricole à Sofia qu'on y prévoit la création d'une section entomologique, ouverte la même année et confiée à un entomologiste spécialiste. Malheureusement, par suite des evénements survenus immédiatement après la création de cette station, notamments la guerre Balcanique en 1912—1913, suivie bientôt de la grande guerre européenne et de perturbations intérieures dans notre pays, ladite station, durant les 12 premières années de sa création, ne put développer son oeuvre scientifique et ne fit paraître aucun compte-rendu jusqu'en 1922 inclusivement, et aucune publication n'enregistrait les renseignements recueillis annuellement sur les insects nuisibles. Depuis 1909 à 1922, seules quelques publications privées d'entomologistes du pays apparaient et encore seulement sur quelques espèces d'insectes nuisibles.

Mais à partir de 1923, la station centrale d'expérimentation et de contrôle agricole de Sofia commença à attirer l'attention des autorités compétents et bientôt on lui donna la possibilité de développer quelque peu son oeuvre scientifique. La section entomologique de cette station aborda des recherches un peu plus systématiques sur les insectes nuisibles, en se posant les problèmes suivants:

1. établir quels sont les insectes nuisibles aux plantes cultivées en Bulgarie, quelle est la distribution de chaque espèce, les plantes attaquées et les dégâts causés;
2. étudier la biologie des insectes nuisibles et rechercher les conditions favorisant leur apparition en masse;
3. essayer les moyens employés en général dans la lutte contre ces ennemis, ainsi que trouver de nouveaux moyens encore plus efficaces;
4. vulgariser et organiser la lutte contre les insects nuisibles.

On commença en même temps à recueillir activement les statistiques annuelles concernant les insectes nuisibles, reçues par l'intermédiaire des organes et établissements du ressort du Ministère de l'Agriculture et des Domaines d'État. On recommença la publication de comptes-rendus annuels concernant ces statistiques. De même, les publications privées sur les insectes nuisibles devinrent plus fréquentes.

Selon l'avis de plusieur personnes compétentes les insectes nuisibles causent aux plantes de culture des pertes dépassant trois milliards de leva (soit environ 600 millions de frs. franç.) et diminuent la récolte annuelle d'environ 12 %. Il suffit de citer seulement le *Thrips tabaci*, qui enlève, à la culture du tabac, 70 à 80 millions de frs.; le coléoptère *Entomoscelis adonidis*, cette année, menaçait d'une destruction de 80 à 90 % la culture du

colza (*Brassica rapa oleifera* D. C.). Beaucoup d'arbres fruitiers en plusieurs endroits du pays souffrent des attaques de l'*Eccoptogaster rugulosus, Ecc. amygdali* et *Ecc. mali* et la plus grande partie de leurs fruits devient la proie des insectes. Malgré tout cela, le service entomologique est encore aujourd'hui limité à une simple section de la station expérimentale d'agriculture de Sofia, section dans laquelle ne travaille qu'un seul entomologiste. Ce service doit être élargi. Dans les conditions actuelles, on peut dire qu'en Bulgarie l'étude des insectes nuisibles n'est pas encore suffisamment développée.

4. La lutte contre les insectes nuisibles.

Il en est de même de la lutte contre ces ennemis. A l'exception de quelques exploitations agricoles privées mieux organisées, et des fermes d'État, où ce n'est à peine que ces dernières années qu'on a commencé à employer certains moyens de lutte, celle-ci n'est cependant nulle part encore entreprise en masse et c'est pourquoi, à l'apparition envahissante de quelque espèce, les dévastations sont souvent très considérables. Dans la destruction des insectes nuisibles les moyens mécaniques occupent la première place. On n'a encore que très peu recours aux moyens chimiques malgré une vive propagande dans cette direction. Quant à la lutte biologique elle n'est pas encore entamée.

5. Principales espèces d'insectes nuisibles aux plantes de culture en Bulgarie.

D'après les publications parues jusqu'ici et les renseignements que je possède, jusqu'au 1er juillet 1928, on a constaté comme nuisibles aux plantes cultivées en Bulgarie plus de 550 espèces d'insectes. La liste qui suit enumère les 142 espèces qui ont été reconnues comme particulièrement nuisibles.

Orthoptera.

1. *Calliptamus italicus* L. — attaque les céréales, les prairies et les jardins potagers.
2. *Stauronotus maroccanus* Thunb. — idem.
3. *Gryllotalpa gryllotalpa* L. — att. les jardins et potagers.

Thysanoptera.

4. *Limothrips cerealium* Halid. — les chautes du seigle.
5. *Thrips tabaci* Lind. — les feuilles du tabac.

Rhynchota.

6. *Eurydema ornata* L. — les choux, choux-raves et navets.
7. *Stephanitis (Tingis) pyri* Geoffr. — les feuilles des poiriers et pommiers.
8. *Psylla pyricola* Först. — les jeunes pousses des poiriers.
9. *Chermes abietis* L. — les pousses de l'année de picea.
10. *Phylloxera vastatrix* Planch.
11. *Tetraneura ulmi* De Geer. — les racines du maïs, rarement le froment.
12. *Eriosoma lanigera* Hausm.

13. *Aphis rumicis* L. (= *papaveris* Fabr.). — les haricots, les fèves, etc.
14. *Aphis maidis* Schrk. — le maïs.
15. *Aphis gossipii* Glov. — les potirons, les pastèques, les melons et les concombres.
16. *Aphis pomi* De Geer. — les pommiers et les poiriers.
17. *Anuraphis chelichrysi* Kalt. — les pruniers.
18. *Myzuz cerasi* L. — les cerisiers.
19. *Brevicoryne brassicae* L. — les choux.
20. *Eulecanium (Lecanium) corni* Bch. — les pruniers, les abricotiers, les pêchers.
21. *Eulecanium persicae* F. — la vigne.
22. *Pulvinaria betulae* Sign. — idem.
23. *Aspidiotus ostreaeformis* Curt. — les poiriers, les pommiers et les pruniers.
24. *Lepidosaphes ulmi* L. (= *Mytilaspis pomorum* Bch.) — les pommiers et l'érable.
25. *Chionaspis salicis* L. — les peupliers et les saules.

Lepidoptera.

26. *Aporia crataegi* L. — tous les arbres fruitiers et quelques espèces sylvicoles.
27. *Pieris rapae* L. — les choux et autres crucifères.
28. *Pieris daplidicae* L. — idem.
29. *Pieris brassicae* L. — idem.
30. *Cnethocampa pityocampa* Schiff. — les aiguilles des pins.
31. *Hypogymna morio* L. — diverses herbes de prairies.
32. *Nygmia phaeorhoea* Don. *(Euproctis chrysorrhoea* L.) — les arbres fruitiers et les arbres de forestiers.
33. *Stilpnotia salicis* L. — les peupliers.
34. *Porthetria dispar* L. — les feuilles de toutes les espèces arboricoles et sylvicoles.
35. *Malacosoma neustria* L. — idem.
36. *Euxoa tritici* L. — les sarments de la vigne, les jeunes plantes de tabacs, le maïs vert.
37. *Rhyacia ypsilon* Rott. — idem.
38. *Barathra brassicae* L. — les choux, les pois, les haricots, les potirons, les salades, les betteraves, les tabacs.
39. *Polia oleracea* L. — idem.
40. *Diloba caeruleocephala* L. — les feuilles des pommiers, de même les pruniers.
41. *Laphigma exigua* Hbn. — les feuilles des betteraves et des tabacs.
42. *Phytometra gamma* L. — les jardins potagers.
43. *Chloroclystis rectangulata* L. — les bourgeons florales et les feuilles des pommiers, des poiriers et les cerisiers.
44. *Ino ampelophaga* Bayle. — les feuilles de la vigne.
45. *Cosses cossus* L. — le pommier, l'orme, le frêne, le tilleul.
46. *Ephestia elutella* Hbn. — les tabacs secs et les fruits secs.
47. *Ephestia kuehniella* Z. — les farines.
48. *Loxostege sticticalis* L. — les prairies et les légumes.

49. *Pyrausta nubilalis* Hbn. — le chanvre souvent et plus rarement le maïs.
50. *Cacoecia rosana* L. — les feuilles des pommiers, poiriers, et des roses.
51. *Tortrix xylostana* L. — idem.
52. *Tortrix viridana* L. — les feuilles du chêne.
53. *Rhyacionia buoliana* Schiff. — les bourgeons et les jeunes pousses du pin.
54. *Argyroploce variegana* Hbn. — les bourgeons et les feuilles terminales des pruniers, des poiriers et des pommiers.
55. *Olethreutes pruniana* Hbn. — les feuilles du prunier, cerisier, griote, pommier et du poirier.
56. *Polychrosis botrana* Schiff. — les fleurs et les fruits de la vigne.
57. *Cydia funebana* Tr. — les fruits du prunier.
58. *Cydia pomonella* L. — les fruits du pommier, poirier.
59. *Hyponomeuta malinellus* Zell. — les feuilles du pommier.
60. *Hyponomeuta padellus* L. — les feuilles du prunier.
61. *Plutella maculipennis* Curt. (= *cruciferarum* Zell.) les feuilles du choux, du colza, et d'autres crucifères.
62. *Sitotroga cerealella* Oliv. — les grains secs de maïs, rarement du froment.
63. *Tinea granella* L. — le froment en magasin et les legumes secs.

Coleoptera.

64. *Zabrus tenebrioides* Goeze (= *gibbus* F.) — les parties de la plante près du collet chez les jeunes pousses du froment, seigle et de l'orge.
65. *Meligethes aeneus* F. — diverses crucifères.
66. *Laemophloeus ferrugineus* Steph. — les grains secs et semences.
67. *Silvanus surinamensis* L. — le froment emmagasiné.
68. *Subcoccinella globosa* Schn. — les feuilles du trèfle, de la luzerne, du sainfoin.
69. *Capnodes tenebrionis* L. — les racines des abricotiers, pruniers, poiriers, cerisiers, griottes.
70. *Agrilus viridis* L. — les pousses de deux ans de la rose et les arbres fruitiers.
71. *Agriotes lineatus* L. — les semences et semis des blés.
72. *Lasioderma serricorne* F. — les tabacs secs, le pain et les produits panifiès de blé, etc.
73. *Lytta vesicatoria* L. — les feuilles des lilas, du frêne, etc.
74. *Teratholytta dives* Brull. v. *togata* Froel. — les jeunes feuilles et pousses des poiriers.
75. *Omophlus lepturoides* F. (= *betulae* Hbst.) — les fleurs et les pousses de l'année des arbres fruitiers, de la vigne, du seigle, du froment.
76. *Opatrum sabulosum* L. — les racines de la vigne et de l'arachide.
77. *Tenebrio molitor* L. — les farines.
78. *Tribolium navale* F. — le froment emmagasiné.
79. *Lema melanopus* L. — les feuilles de l'avoine et de l'orge.
80. *Labidostoma propinqua* Fald. — les jeunes feuilles du poirier, du cerisier, de l'abricotier.
81. *Phytodecta fornicata* Brüggem. (= *sexpunctata* Panz.) — les feuilles de la luzerne.

82. *Entomoscelis adonidis* Pall. — les feuilles et les siliques du colza.
83. *Phyllotreta atra* F. — les légumes, le chanvre, le lin, etc.
84. *Phyllotreta cruciferae* Goeze. — idem.
85. *Phyllotreta undulata* Kutsch. — idem.
86. *Phyllotreta nemorum* L. — les choux et autres légumes.
87. *Laria pisorum* L. — les pois.
88. *Laria lentis* Fröl. — les lentilles.
89. *Laria granaria* L. — les verces.
90. *Phyllobius oblongus* L. — les feuilles des arbres fruitiers.
91. *Otiorrhynchus lugustici* L. — les serments, les fèves, les betteraves, la luzerne.
92. *Otiorrhynchus lavandus* Germ. — la vigne.
93. *Otiorrhynchus turca* Boh. — idem.
94. *Sitona lineata* L. — les fèves, les trèfles, les pois.
95. *Sciaphobus squalidus* Gyll. — les bourgeons et les jeunes pousses du cerisiers, du poiriers et du tilleul.
96. *Pissodes notatus* L. — les rameaux du pin.
97. *Pissodes pini* L. — idem.
98. *Anthonomus pomorum* L. — les bourgeons florales des pommiers et plus rarement des poiriers.
99. *Calandra granaria* L. — froment et le seigle emmagasiné.
100. *Rhynchites auratus* Scop. — les jeunes fruits des cerisiers, des pommiers, poiriers, griotes, pruniers, etc.
101. *Rhynchites pauxillus* Germ. — les bourgeons florales et les feuilles des cerisiers, griottes, pommiers, poiriers, etc.
102. *Rhynchites bacchus* L. — les jeunes fruits des pommiers, poiriers, abricotiers.
103. *Rhynchites cupreus* L. — les jeunes fruits des pruniers.
104. *Eccoptogaster scolytus* Fabr. — le tronc et les branches plus grosses de l'orme.
105. *Eccoptogaster mali* Bechst. — le tronc et les branches plus grosses du pommier et du cerisier.
106. *Eccoptogaster rugulosus* Ratz. — le tronc et les branches de tous les arbres fruitiers.
107. *Eccoptogaster amygdali* Guér. — le tronc et les branches des pruniers, griottes et des abricotiers.
108. *Scolytochelus multistriatus* Mrsh. — le tronc et les branches plus grosses de l'orme.
109. *Hylesinus oleiperda* F. — attaque l'érable.
110. *Hylesinus fraxini* Panz. — idem.
111. *Pteleobius vittatus* F. — le tronc et les branches plus grosses de l'orme.
112. *Blastophagus piniperda* L. — le tronc, les rameaux plus gros et les pousses de l'année du pin.
113. *Cryphalus piceae* Ratz. — le tronc et les rameaux du sapin et le picea.
114. *Anisandrus dispar* F. — attaque le tronc et les rameaux de la vigne, pommiers, abricotiers et des pruniers.
115. *Pityogenes quadridens* Hart. — le picea et les diverses variétés de pin.

116. *Pityogenes chalcographus* L. — le picea, le sapin et les diverses variétés de pin.
117. *Pityogenes bistridentatus* Eichh. — les diverses variétés de pin.
118. *Pityophthorus pityographus* Ratz. — le sapin, le picea, le melèze et Pinus leucodermis.
119. *Ips typographus* L. — le picea.
120. *Lethrus apterus* Laxm. — les pousses de l'année de la vigne.
121. *Amphimallus solstitialis* L. — les céréales et les vignes.
122. *Anomala aurata* F. — les feuilles des arbres fruitiers, les vignes, les peupliers, les tilleuls et du maïs.
123. *Anomala aenea* De Geer. — idem.
124. *Blithopertha lineolata* Fisch. — les haricots, les potagers, les pruniers et les poiriers.
125. *Anisoplia austriaca* Hbst. — le fromant, le seigle et l'orge.
126. *Anisoplia cyanthygera* Scop. — idem.
127. *Anisoplia segetum* Hbst. — idem.
128. *Anisoplia lata* Er. — idem.
129. *Epicometis hirta* Poda. — les fleurs des arbres fruitiers, des blés, de la vigne et beaucoup de légumes et d'autres cultures en fleurs.
130. *Oxythyrea stictica* L. — idem.

Diptera.

131. *Hylemyia antiqua* Mg. — les bulbes de l'oignon et de l'ail.
132. *Hylemyia brassicae* Bch. — les racines des choux.
133. *Rhagoletis cerasi* L. — les fruits du cerisier et de la griotte.
134. *Chlorops taeniopus* Mg. — attaque le froment, l'orge et le seigle.
135. *Lasiosina cinctipes* Mg. — l'orge.
136. *Osciniosoma frit* L. — l'orge et l'avoine.

Hymenoptera.

137. *Acantholyda erythrocephala* L. — les aiguilles des pins.
138. *Hoplocampa fulvicornis* Klug (= *minuta* Chryst.) — les jeunes fruits du prunier.
139. *Hoplocampa testudinea* Klug — les jeunes fruits du pommier.
140. *Eriocampoides limacina* Ratz. (= *Selandria adumbrata* Klug) les feuilles du poirier, cerisier, de la griotte et du prunier.
141. *Syrista pareyssi* Spin. — les pousses de l'année des roses et des églantiers.
142. *Eurytoma amygdali* Enderl. — les fruits des. amandiers.

6. Caractéristique des insectes nuisibles en Bulgarie.

Parmi les diverses espèces de Sauterelles nuisibles en Bulgarie, seule les espèces *Calliptamus italicus* L. et *Stauronotus maroccanus* Thunb. ont été notées comme très nuisibles. Leur apparition en masse cependant n'a lieu que par intervalles de plusieurs années, généralement d'une facon locale; rarement elle embrasse de grandes étendues.

Thrips tabaci Lind. — Répandu en masse partout où l'on cultive le tabac et cause d'énormes pertes à cette culture (70 à 80 millions de frs annuellement, comme dit plus haut).

Phylloxera vastatrix Planch. a atteint et détruit presque toutes les vignes à souche locale.

Le puceron lanigère (*Eriosoma lanigerum* Hausm.) est de même très répandu dans tout le pays. Les variétés étrangères de pommier en souffrent particulièrement; les variétés indigènes sont plus résistantes.

Parmi les cochenilles, la plus nuisible chez nous est l'*Eulecanium (Lecanium) corni* Bch. des pruniers.

Les chenilles de la *Porthetria dispar* L. apparaissent en masse, en certaines localités, 1 à 2 ans, puis disparaissent complètement durant plusieurs années. Mes observations à ce propos m'ont amené à reconnaître que la cause de leur disparition réside uniquement dans les parasites de ces chenilles, qui se multiplient rapidement en masse. Ainsi, en 1924, dans certains villages de l'arrondissement de Kazanlik, ces chenilles étaient apparues en masse sur les arbres fruitiers et le chêne, mais l'année suivante leur nombre diminua de beaucoup, et durant les années 1926 et 1927 il n'y avait plus même de trace de leurs oeufs. La même chose fut constatée dans le département de Bourgas, où en 1926 ces chenilles avaient détruit les feuilles des forêts de chênes dans la proportion de 50 à 100 %. Là aussi l'année suivante il y en avait très peu et cette année-ci on ne put presque plus en découvrir.

La teigne bariolée de la vigne (*Polychrosis botrana* Schiff.), bien répandue dans tout le pays, cause des dégâts principalement aux treilles. Dans les vignobles son apparition n'est devenue menaçante que depuis 3 ou 4 ans.

Le *Loxostege (Phlyctaenodes) sticticalis* L. se rencontre dans tout le pays, mais une seule fois, en 1919—20, ce papillon est apparu en masse, sur de grandes étendues, en causant de grandes pertes aux prairies, à la betterave, aux légumes et à d'autres cultures.

Le papillon *Pyrausta nubilalis* Hbn. est de même répandu dans tout le pays, mais jusqu'ici il n'a pas attaqué, sur une grande étendue, le maïs, mais au chanvre, dans l'arrondissement de Tatar-Pazardjik, il cause souvent de très grands dégâts.

Cydia pomonella L. et *Cydia (Grapholitha) funebrana* Hbn. détruisent la moitié des fruits du pommier et du prunier chez nous.

Sitotroga cerealella Oliv. cause de grands dégâts dans la Bulgarie du nord, aux grains de maïs en magasin.

Les larves du coléoptère *Capnodes tenebrionis* L. causent, en maints endroits, le dessèchement en masse des jeunes plantes d'arbres fruitiers, surtout dans les pépinières.

Beaucoup de nos rosiers délaissés des arrondissements de Kazanlik et de Karlovo souffrent de l'*Agrilus viridis* L.

La *Phytodecta fornicata* Brüggm. (= *sexpunctata* Panz.) se présente comme une ennemie très sérieuse de la luzerne et y cause de grosses pertes à la première coupe.

Entomoscelis adonidis Pall. est l'ennemi le plus sérieux du colza (*Brassica rapa oleifera* D. C.), dont la culture est sérieusement menacée en Bulgarie.

Le charançon bien connu *Bothynoderes punctiventris* Germ. n'a pas été constaté en masse et n'est pas accusé de causer de grandes pertes à la betterave, bien qu'il se rencontre dans le pays.

Parmi les coléoptères de la famille *Ipidae*, les plus nuisibles sont: *Eccoptogaster rugulosus* Ratz. et *Ecc. amygdali* Guér., pour les arbres fruitiers, et *Blastophagus piniperda* L. pour le pin. *Ips typographus* L. n'a pas chez nous la grande importance qu'il présente dans certains autres pays; en Bulgarie, il est rarement très nuisible au Picea excelsa.

Parmi les espèces d'insectes nuisibles connues jusqu' ici de Bulgarie les plus caractéristiques sont les suivantes:

1) *Capnodes tenebrionis;* 2) *Teratholytta dives* v. *togata* Froel.; 3) *Otiorrhynchus turca* Boh.; 4) *Phyllobius rhodopensis* Apf.; 5) *Eccoptogaster orientalis* Eggers; 6) *Dryocoetes leonhardi* Eggers; 7) *Pseudotrematodes frivaldskyi* Mén., et 8) *Eurytoma amygdali* Enderl.

Liste des publications les plus importantes sur les insectes nuisibles parues en Bulgarie.

1. Bourèche, Dr. Iv. — Histoire de l'étude entomologique de la Bulgarie (Oeuvres de l'Institut scientifique et agronomique bulgare, No. 8, pp. 3 à 136. Sofia 1924).
2. — — Recherches sur la biologie de la teigne des vignes *Polychrosis botrana* Schiff. et les procédés de sa destruction. (Revue des Instituts d'expérimentation agricole en Bulgarie, année III, fascicules 2 et 3, pp. 271 à 300. Sofia 1925).
3. Vassilev, Panaïote. — Un nouvel ennemi de la vigne en Bulgarie: La teigne de la vigne (description, développement et lutte contre cet ennemi). Edition du Conseil général de Kustendil, No. 3, pp. 48. Kustendil 1922).
4. Ghiorguiev, Iv. — Contribution à l'étude de la biologie de l'Eudemis *(Polychrosis botrana* Schiff.) et les moyens de lutte contre cet ennemi (Annuaire de l'Université de Sofia. Faculté d'agronomie et de sylviculture, fascicule VI, 1927—1928, pp. 13 à 54. Sofia 1928).
5. Grigoriev, V. — Notes sur la biologie du thrips des tabacs (Travaux scientifiques de la Société bulgare d'Agriculture, pp. 3 à 56. Sofia 1926).
6. Dospevski, Dr. C. — Recherches et observations sur diverses maladies et ennemis des plantes de culture (Extrait du Compte rendu de la Station expérimentale d'agriculture de Sadovo pour l'année 1907, pp. 1 à 75. Plovdiv 1908).
7. — — Recherches et observations sur les maladies et ennemis des plantes de culture (Compte Rendu de la St. expérim. d'agriculture de Sadovo, année VI — 1908, p. 86 à 134. Plovdiv 1910).
8. Drenovsky, Al. — *Chlorops taeniopus* Mg., le Chlorops des céréales, les dégâts qu'il cause et la lutte entreprise contre lui dans l'arrondissement de Sofia (Archive du ministère de l'agriculture et des domaines d'Etat, tome II, pp. 1 à 32. Sofia 1922).
9. — — *Lasiosina cinstipes* Mg., la mouche des épis de l'orge, les dégâts causés par elle dans l'arrondissement de Sofia et la lutte possible contre cet ennemi (Renseignements agricoles, annéc VI, numéros 3 et 4, pp. 3 à 36. Sofia 1923).
10. — — Les insectes nuisibles du tabac chez nous (Edition du Syndicat coopératif de production de tabacs à Lovetch, pp. 3 à 56. Sofia 1923).
11. — — Une espèce nuisible de chenille sur les pins chez nous, *Thaumatopoea pityocampa* Schiff. (Revue "gorski préglède", année IX, No. 7, pp. 234 à 247. Sofia 1923).
12. Enderlein, Dr. Günther et Drenovski, Al. K. — Quelques nouvelles mouches nuisibles des céréales en Bulgarie (Archive du ministère de l'agriculture, tome III, Sofia 1923).
13. Iltchev, D. — Le ver gris *(Agrotis tritici* L.) comme ennemi de la vigne (Renseignements agricoles, année IV, No. 2, pp. 14—26. Sofia 1923).
14. — — Le coléoptere velu des fleurs des arbres fruitiers et des céréales (Renseign. agr., année IV, No. 2, pp. 5—13. Sofia 1923).

15. Joakimov, D. — Biologie de la guêpe à tête rouge du pin, *Acantholyda (Lyda) erythrocephala* L., les dégâts qu'elle cause et les moyens pour sa destruction (Annuaire de l'Université de Sofia; faculté des sciences, fascicule I-a, 1923, 8 à 137. Sofia 1923).
16. Konsoulov, Dr. St. — Notes sur les ennemis de la rose (ibid,. fascicule XIX, pp. 306 à 320. Sofia 1923).
17. Kozarov, Dr. P. — Statistique des maladies et des dégâts sur les plantes de culture dans la Bulgarie septentrionale pour l'année 1907 (Oeuvres de la station exp. d'agr. d'Etat à Obrastzov-Tchiflik près de Roussé, tome I, partie 2, pp. 37 à 79, Varna 1907; t. I, partie 2, pp. 209 à 215, Varna 1908).
18. — — Liste des maladies et ennemis des plantes de culture constatés dans la Bulgarie septentrionale en 1907 (ibid., t. I, partie 2, pp. 215 à 256, Varna 1908).
19. — — Maladies et ennemis des plantes de culture dans la Bulgarie septentrionale en 1908 (ibid., t. II, partie 1, pp. 68 à 148, année 1909, et t. II, partie 2, pp. 73 à 102, Varna 1910).
20. Malkov, K. — Description succincte des maladies et dégâts les plus répandus sur les cultures agricoles et les arbres fruitiers, parus au cours des années 1903 et 1904 dans la Principauté (Compte rendu annuel de la Station expérimentale d'agriculture de Sadovo, année II—1903, pp. 87 â 233. Plovdiv 1905).
21. — — Description des principales maladies et pertes occasionnées aux plantes de culture dans le courant de 1905 dans la Principauté de Bulgarie (ibid., III—1905, pp. 121 à 140. Plovdiv 1906).
22. — — Un insecte très nuisible aux amandiers, paru à Starà-Zagora (ibid., III—1905, pp. 162 à 164. Plovdiv 1906).
23. — — Contribution à l'étude des insectes nuisibles aux plantes de culture chez nous (Oeuvres de la Station exp. d'agr. de Sadovo, No. 2, pp. 47 à 54. Plovdiv 1907).
24. — — Description de quelques maladies et ennemis des plantes agricoles, parus dans le courant de l'année 1906 dans la Principauté (ibid., année IV—1906, pp. 158 à 176. Plovdiv 1907).
25. — — Recherches et observations sur diverses maladies et ennemis des plantes de culture (ibid., V—1907, pp. 193 à 307. Plovdiv 1908).
26. Mocrzecki, Prof. S. A. — Sur la biologie de quelques nouveaux ennemis des roses en Bulgarie (*Agrilus foveicolis* Mars. et *Sirysta parreyssi* Spin.) (Oeuvres de la société des naturalistes bulgares, année IX, pp. 117 à 126. Sofia 1921).
27. Naïdénov, V. — La sauterelle italienne et la lutte en général contre les sauterelles (Bibliothèque agricole populaire, p. 48, 1920).
28. Petkov, P. — Le dépérissement en masse du Caliptamus italicus L. en 1919 (Revue de l'Institut expér. d'agric. en Bulgarie, année II, fascicule 1 et 2, pp. 48 à 61. Sofia 1921).
29. Rouskov, M. — Quelques insectes nuisibles à nos forêts, constatés dans le courant de l'année 1927 (Avis de la société entomologique bulgare, année IV, pp. 57 à 64. Sofia 1927).
30. Tchorbadjief, P. — Insectes et autres animaux nuisibles constatés sur les plantes de culture en Bulgarie en 1923 (Renseignements agricoles, année V, fasc. 3 et 4, pp. 6 à 26. Sofia 1924).
31. — — Les scolytiens nuisibles aux arbres fruitiers chez nous et la lutte contre eux (Oeuvres de l'Institut scientifique et agronomique bulgare, No. 7, pp. 1 à 32. Sofia 1924).
32. — — La teigne des céréales (*Sititroga cerealella* Oliv.) et les moyens de lutter contre elle (Feuille volante No. 12, édition de l'Institut d'expérim. agr. de Sofia. 1924).
33. — — Les ennemis animaux des plantes de culture en Bulgarie en 1924 (Renseignements agricoles, année VI, fasc. 4, 5 à 6, pp. 3 à 20. Sofia 1925).
34. — — Compte rendu de la section entomologique pour l'année 1923 (C. R. annuel de l'Institut d'expér. agr. à Sofia, année 1923, pp. 99 à 109. Sofia 1925).

35. — — Contribution à l'étude des parasites des insectes nuisibles en Bulgarie (Avis de la Société entomologique bulgare, fascicule II, pp. 84 à 89).

36. — — C. R. annuel de la section entomologique pour l'année 1924 (C. R. an. de l'Institut d'expérim. agr. à Sofia pour 1924, pp. 165 à 185. Sofia 1925).

37. — — Les pucerons des feuilles d'orme *(Tetraneura ulmi* De Geer) sur les racines du maïs (Renseignements agricoles, année VII, fasc. 3, pp. 3 à 13. Sofia 1926).

38. — — Les sauterelles nuisibles en Bulgarie (espèces, propagation, dégâts et organisation de la lutte contre elles) (Avis de la Société entomologique bulgare, fasc. 3, pp. 71 à 88. Sofia 1926).

39. — — Notes sur quelques ennemis animaux des plantes de culture en Bulgarie constatés en 1925 (ibid., bulgare, fasc. 3, pp. 115—134. Sofia 1926).

40. — — Les ennemis des plantes de culture en Bulgarie durant l'année 1926 (Renseign. agr. an. IX, fasc. 3—4, pp. 3 à 51. Sofia 1928).

41. — — Le coléoptère du colza, *Entomoscelis adonidis* Pall., en Bulgarie (Avis de la Sociéte entomologique bulgare, fasc. 4, pp. 65 à 90. Sofia 1928).

42. — — Liste des scolytiens *(Ipidae)* en Bulgarie (ibid., fasc. 4, pp. 135 à 140. Sofia 1928).

43. — — Notes sur quelques nouveaux et rares insectes nuisibles en Bulgarie, observés dans le courant des années 1926 et 1927 (ibid., fasc. 4, pp. 125—134. Sofia 1928).

44. — — Contribution à l'étude des scolytides *(Ipidae)* en Bulgarie (Sous impression dans la Revue de l'Academie des sciences. Sofia 1928).

45. — — C. R. annuel de la section entomologique pour 1925 (C. R. de la Station d'expérim. et de contrôle agricoles de Sofia, année 1925, pp. 205 à 257. Sofia 1927).

Septicemia of the Honeybee.

C. E. Burnside, Assistant Apiculturist, Bureau of Entomology.
United States Department of Agriculture, Washington, D. C.

(With 4 text-figures.)

Introduction.

Beekeepers are well aware that adult bees at times suffer from disturbances which take a considerable toll from the population of the infected colonies and consequently from the honey crop. Owing to the less apparent serious nature of diseases of adult bees, they have received much less attention from investigators than have the diseases of the brood. No widespread outbreaks of adult bee diseases have occurred in America such as that caused in England by the parasitic mite *Acarapis woodi* (Rennie).

Since the work of Zander (7) in 1909 on *Nosema apis*, a number of other micro-organisms have been found which cause diseases of adult bees. However, the regrettable fact still remains that in the greater number of cases when bees, which appear to have died abnormally, are examined by laboratory methods, no cause for the trouble can be found. It is evident, therefore, that there is a need for further study of the diseases that affect the adult bee.

Septicemia*) of adult honeybees is an infectious disease caused by an actively motile bacillus found in the blood, which causes the death of many bees and thus tends to weaken colonies.

The percentage of deaths in an individual colony is comparatively small and it is seldom that a colony is destroyed by it. Heavy infection is usually limited to one or a few colonies within am apiary, although the disease can usually be found readily in other colonies.

The losses which result from septicemia are less than from American foulbrood, European foulbrood, or from *Nosema* disease, and perhaps may be more comparable to the losses from sacbrood. Unlike *Nosema* disease, bees with septicemia die quickly, thus at any one time but a comparatively few infected bees can be found. A bee infected with septicemia dies within a few hours, while one with *Nosema* may live for days. On the other hand, no serious outbreak of septicemia has been reported.

More than forty years ago, Cheshire (3) examined the blood of adult bees from a colony infected with foulbrood and found it "laden with bacilli." However, he wrongfully supposed that he had demonstrated the occurrence of foulbrood in adult bees. Cheshire also observed bacteria in the blood of adult bees upon other occasions. From the blood smear of a bee, he figures two organisms which he says "appeared to be the occasion

*) In an earlier paper the writer (2) refers to the discovery, symptoms of the disease, some cultural characteristics of the organism, and other facts that were determined by experiment and the examination of the samples of adult bees sent to the Bee Culture Laboratory for diagnosis of disease.

of a most destructive attack." At another time, while examining a queen that had become too weak to remain on the combs, he found the blood thin and milky and filled with bacteria, which he thought were micrococci. He describes the whole body of the bee as "completely broken down."

The symptoms given here and the figure of the organism present in the blood of the queen compare favorably with those observed by the writer in cases of septicemia. The high percentage of short, almost spherical rods found in blood smears of bees with septicemia give to the blood much of the appearance of infection by a micrococcus.

Still another organism found in the blood of an abnormal queen is poorly figured and incompletely described by Cheshire, who expresses his belief that in every case micro-organisms which are found in the tissue and blood of bees are pathogenic.

In 1922 Bahr recovered from the blood of infected bees *Bacillus paratyphus alvei*. This bacillus and an intestinal disease of adult bees caused by it, were named and described by him (1). It appears that he did not consider the presence of the organism in the blood of bees of much importance, since he made no mention of suspecting it to be the cause of septicemia.

The Blood of Adult Bees.

In septicemia the parasite multiplies and spreads within the blood of the infected bees. The blood of adult honeybees has been described (4) as a pale, brownish liquid which contains a few granular leucocytes. In the bee, as in other insects, there are no special blood vessels such as veins and arteries, but there are definite spaces within the body through which the blood flows. The chief propelling organ is the heart. The blood comes into the dorsal sinus by way of the lateral openings above the edges of the diaphragm, and then enters the heart through the ostia ... The heart pumps the blood anteriorly through the aorta and finally into the cavity of the head. From the head, it makes its way backward through the thorax and enters the ventral sinus of the abdomen, where it is forced backward by the wave-like vibrations of the ventral diaphragm. Thus the blood has a definite circulation through the larger spaces of the body cavity. It also bathes all of the tissues of the body and penetrates all of the appendages.

The respiratory gases are exchanged between the air and the blood through the extremely thin walls of the tracheoles, which wind about over the surface of all the internal organs, penetrate between the muscle fibers and amongst the cells of other tissues. In speaking of the thinness of the walls of the tracheoles, Snodgrass (4) says that "their delicate walls are very difficult to follow in dissections."

The organism is readily cultured in a number of media commonly used in bacteriological work. Cultures were obtained by washing the outside of diseased bees with a disinfectant and removing the head. The drop of blood which usually appears when the head is removed was plated directly or first diluted with water. Apparently pure cultures were obtained directly by this process. However, the usual method of plating and isolation was always employed. A liquid medium containing peptone and sodium chloride in addition to 1% of the sugar to be tested was used in determining the fermentive changes produced by cultures in various carbohydrates. Or-

dinary room temperature and 36° C were used for most of the culture work.

Bacillus apisepticus. *) — This species grows well on a variety of media ordinarily used in the laboratory. Good growth is obtained in media whose reaction varies from pH 5 to pH 9. A wide range of temperature is suitable for incubation. Growth is more rapid at 37° C than at room temperature.

Morphology: The organism from agar is rod-shaped. The greater number of rods are oval, many appear almost spherical, short rods with rounded ends are plentiful and longer rods occur in chains. In the blood of infected bees, the percentage of long rods is less than on agar (text-figs. 1 and 2). The spherical forms measure approximately 0.6 to 0.7 μ; the oval

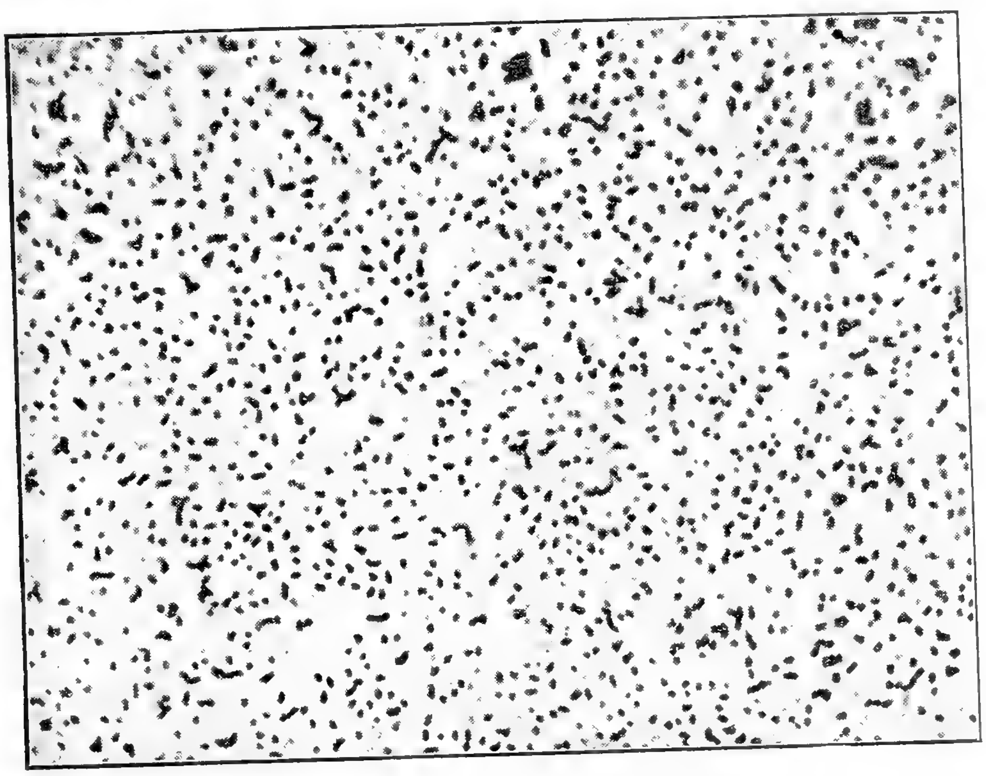


Fig. 1. *Bacillus apisepticus* from a nutrient agar culture.

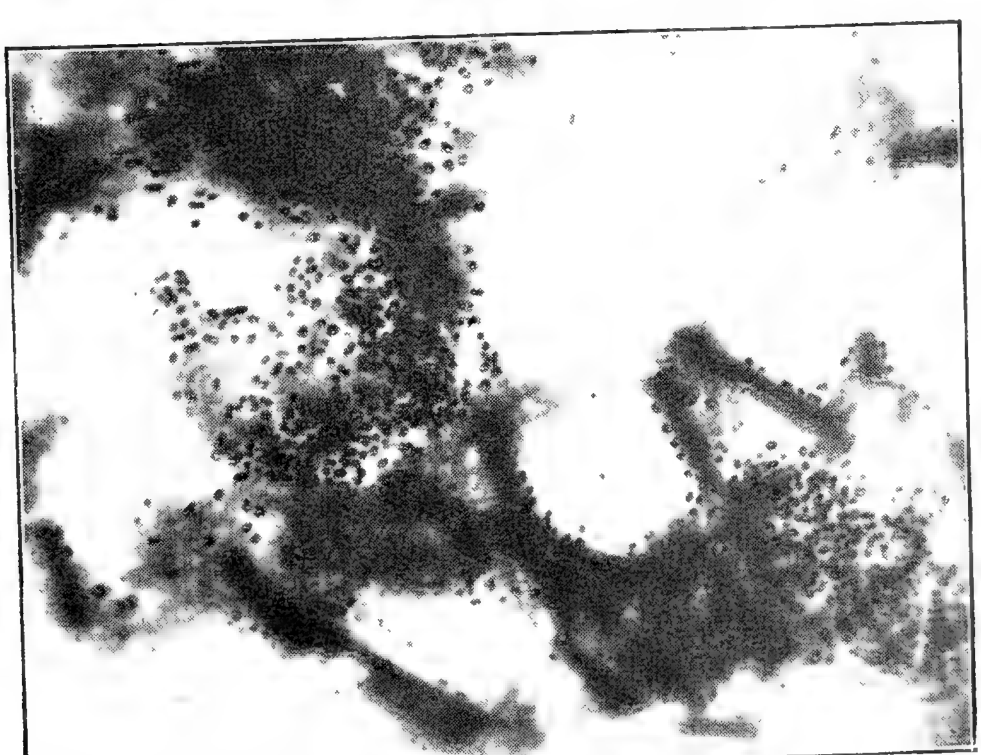


Fig. 2. Stained smear of the blood of a bee dead of septicemia.

*) This name, which was given to the organism by the writer (2), was suggested by Dr. G. F. White.

and elliptical forms 0.6 to 0.7 μ by 0.8 to 1.5 μ. The rods are often 0.6 to 1.0 μ by 1.5 to 3.0 μ; longer rods are not uncommon. In bouillon the dimensions are slightly greater than on agar. Spores are not formed in any of the media employed.

Motility: The organism is actively motile, the movements being progressive and whirling. The ends often progress in a spiral course about a more or less central axis. In broth most of the rods are motionless after three days, but a few are active after a week.

Staining properties: The organism stains readily and is gram negative.

Agar plates: Colonies develop rapidly on agar plates. The margin is at first entire, but often becomes amoeboid and spreads rapidly on freshly poured plates (text-fig. 3). The colonies are slightly elevated and granular

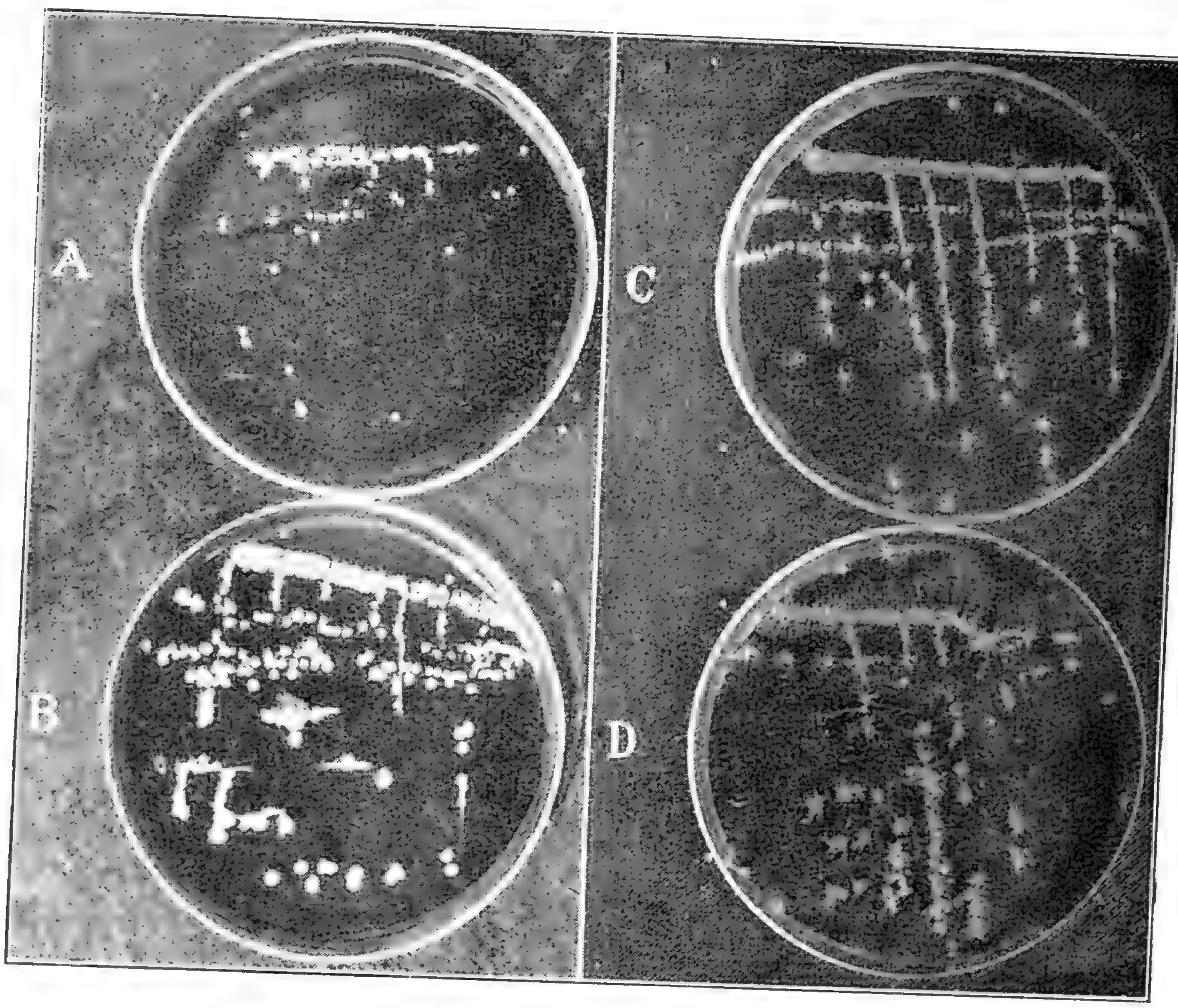


Fig. 3. Colonies of *Bacillus apisepticus* on agar, twenty-four hours old, A, and B sixty hours old; C and D, arborescent growth of *Bacillus apisepticus.*

and their surface appears moist and glistening. They are grayish white by reflected light and bluish by transmitted light. Pigments are sometimes produced. One of the writer's cultures produced a brownish pigment through many generations in culture; another produced a transient yellowish green pigment for only three generations.

Agar slant: A slightly raised grayish white growth occurs along the inoculated surface.

Gelatin plates: Gelatin is liquefied by most strains. At room temperature after 24 hours, the colonies are surroundel by a depressed area of liquefaction, which increases with the growth of the organism.

Gelatin stab: After 24 hours at room temperature a white line of growth is present. Liquefaction is first noticed at the surface. The liquefied portion is at first depressed; later it becomes infundibuliform and is complete in from one to two weeks.

Potato: A grayish white growth occurs which covers the surface. Gas is formed. The potato becomes brownish, the color deepens and finally becomes almost black.

Bouillon: Within 24 hours the medium is cloudy throughout. A sediment is formed within 48 hours, and gas may form. A ring usually forms which clings to the side of the glass, a thin pellicle may form.

Milk: Within a day a soft coagulum appears (within 3 days with one strain), which is slowly digested. About $^1/_4$ of the coagulum is digested within a week and more than $^3/_4$ within a month.

Litmus milk: The medium becomes slightly acid within a day. Acidity increases to about the third day. The color is discharged.

Carbohydrates:

Table.

Indicating acid formation in some carbohydrates and in salicin of two culturea of *B. apisepticus*. Both cultures were isolated from bees at Somerset, Maryland.

Culture	Acid formation																
	Dextrose	Saccharose	Maltose	Lactose	Levulose	Galactose	Mannose	Raffinose	Dextrin	Inulin	Erythrite	Mannite	Arabinose	Melozitose	Salicin	Xylose	Starch
No. 1. Acid reaction after 3 days.	5.4	5.4	5.6	7.4	6.6	5.6	5.6	7.0	7.4	6.6	6.8	5.6	6.6	7.4	6.0	6.4	6.6
No 2. Acid reaction after 3 days	5.0	5.6	5.8	7.0	6.8	6.4	5.4	7.2	6.6	7.2	6.8	6.2	7.0	7.4	5.0	6.8	6.8

Dunham's solution containing 1 per cent of the carbohydrate was used in making the determinations recorded in the table. The acid reaction of the medium before it was affected by the organism was about 6.6. The numbers in the table indicate the pH value of the medium in three days old cultures. No gas was formed with these cultures, but small amounts were formed in a few carbohydrates with other strains obtained from different sections of the United States.

Resistance and Viability.

Cultures remain alive over long periods in liquid media and in sealed agar cultures. Slants kept at room temperature in dim light were viable after eight months, but cultures on agar slants kept near a window and exposed to direct sunlight for an hour or more daily were dead after six months. Cultures in broth were alive after nine months, while the organism from agar in aqueous suspension showed no noticeable dying out after six months. In sterilized wet humus soil kept in flasks in dim light, the organism remained alive for more than eight months.

The organism dies out quickly upon drying, and in water which is allowed to evaporate it is dead in less than a day after it has become dry. In water at 98° C it is dead in less than two minutes. In aqueous suspension in test tubes in direct sunlight it is killed in less than four hours. On agar slants exposed to direct sunlight it dies out after about the third day.

Experimental Inoculations.

In preliminary experiments to establish the fact that the organism encountered in the blood of bees is the exciting cause of the disorder, many healthy bees were inoculated by puncturing with a needle dipped into the blood of diseased bees, recently dead ones, or cultures of the organism on agar plates. The inoculated bees soon became infected and a mortality of 100% usually resulted. Bees punctured with a sterile needle or a needle dipped into the blood of healthy bees were not noticeably affected. This method of infection could scarcely occur in nature, because of the constant protection afforded by the exoskeleton.

The organism suspended in water or dilute sugar solution was fed to bees in cages and in colonies. With this method the percentage of infection remained low, usually from 3 to 10% and rarely as high as 20%. When the bees had access to a suspension containing the organism for a day the percentage of mortality remained low, and the same rate of mortality continued as long as the bees had access to the organism. Check cages were always used in conjunction with the feeding experiments. But little mortality occurred in colonies which had been fed a suspension of the organism. It should be pointed out at this time that although infection occurred when bees had the organism available in food, infection does not take place through the alimentary tract, as will be explained later.

In a third series of experiments the material containing the organism was allowed to dry before the bees were inoculated with it. Healthy bees were caged on the dried pulverized remains of bees dead of septicemia, or on dried filter papers that had been saturated with an aqueous suspension of *Bacillus apisepticus.* Dead bees, dried and pulverized,, were scattered over the combs of colonies. Only negative results were obtained with the organism in a dry condition. Diseased material that had been macerated and dried for 24 hours failed to cause infection when it was mixed with the food of caged bees.

In another method the inoculations were made with the organism in a wet condition. Bees were confined on the macerated and wet remains of bees recently dead of septicemia, or on filter papers saturated with a water suspension of the organism. Bees in cages and in colonies were also sprayed or submerged for a few seconds in water containing *Bacillus apisepticus.* Following inoculations by these methods, bees were infected in varying numbers. From 20 to 30% of them died of septicemia when caged on the wet remains of dead bees. The percentage was somewhat less when saturated filter papers were used. A high percentage of deaths from septicemia resulted when the bees were sprayed with or submerged in a water suspension of *Bacillus apisepticus.* When heavy water suspensions of the organism were used, usually from 60 to 100% of the inoculated bees died of septicemia.

In addition to the occurrence of *Bacillus apisepticus* in the blood of diseased and dead bees, it was also isolated from the soil. It was found present in abundance in moist humus soil near infected colonies. At a distance of three of four rods from colonies it is present in lesser degree, while it is comparatively rare in sandy soil exposed to direct sunlight. When water was used with which soil from near infected colonies had been washed, the percentage of deaths with four trials was 10, 6, 6, and 0%. Cultures of *Bacillus apisepticus* isolated from the soil were found to be as virulent as cultures from naturally infected bees.

The percentages of deaths obtained in inoculated colonies and in a two pound package of bees compared favorably with those obtained with bees in cages. Approximately 75% of a two pound package of bees died of septicemia following a single wetting. From 60 to 70% of the bees of colonies inoculated by submerging them for a few seconds died within three days. Following second inoculations four days later, nearly 70% of the remaining bees died, leaving the colonies so weakened that they died out within two weeks.

Since the results of inoculation experiments described above indicate that infection occurs through body openings other than the alimentary canal, a series of controlled experiments were performed to determine the portal of entry. Bees were held by the wings while the sides of the thorax were moistened with a brush of camels hair, using an aqueous suspension of *Bacillus apisepticus.* Care was used to prevent any of the water containing the organism from reaching the mouth parts. The bees were caged and provided with honey as food. Twenty-five inoculated bees died of septicemia within 36 hours. Another set of 25 bees were inoculated in this manner, but were placed in individual short glass tubes, lightly plugged with cotton, in such a manner that the inoculum could not get to the mouth parts. After about three hours, when the water had evaporated, these bees were placed in a cage. Within 36 hours all of them had died of septicemia. With the aid of a binocular microscope, the region in the immediate vicinity of a single large spiracle on one side of the propodeum was touched with the camel's hair brush moistened with an aqueous suspension of *Bacillus apisepticus* and a thin film of the culture was spread over it. These bees were caged in individual cells until the water had evaporated. Apparently none of the suspension of bacteria reached the mouth parts. After three days 19 bees had died of septicemia. The remaining 6 bees escaped infection. In another experiment the spiracles on one side of the fifth and sixth abdominal segments were slightly moistened with the culture and the bees kept in individual cells for three hours to keep the suspension from the mouth parts. Concentrated honey was given to this cage of 30 bees after they were released from the cells. After 22 hours 14 of them were dead or dying, and after three days 25 of them were dead of septicemia. Repetitions of these experiments gave similar results. Check bees, moistened about the spiracles with sterile water and given honey as food were apparently unaffected. When fed with an aqueous suspension of *Bacillus apisepticus* or with dilute syrup containing the organism, the death rate among check bees wet about the spiracles with sterile water was not higher than when bees were allowed to walk over an aqueous film of *Bacillus apisepticus.*

Symptoms and Post-Mortem Changes.

In about 16 hours after inoculation the first noticeable symptoms are continued restlessness and feeble efforts to fly. The infected bees refuse food, and progressive weakening continues until the ability to fly is lost. During the early stages of infection, bees appear to recover strength temporarily when exposed to direct sunlight or when removed from a temperature of 25° C to one near 37° C. This apparent recovery is of short duration and death usually occurs within a few hours. In the later stages of disease the general appearance is quite similar to that of chilled bees. Just before death the bees are only capable of feeble movements of the abdomen, legs and mouth parts. During the crawling stage, after the ability to fly is lost, the movements become uncertain and the bees frequently fall. Eventually they become unable to right themselves and die lying on their backs or sides. The highest death rate usually occurs in from 20 to 36 hours after inoculation, and few bees die during the third day.

The blood of sick bees and those that have recently died of septicemia is often found to have lost its pale-brown color and assumed a milky hue. Bacteria are found in large numbers in the blood of the three main body divisions and in the appendages. Smears from the blood of diseased or dead bees usually contain large numbers of short rods. Blood smears from any part of the body are satisfactory for examination, but a loop of blood is obtained most easily by pulling off the head and abdomen and carefully pressing the thorax.

After death putrefactive changes occur rapidly under favorable conditions. The abdomen becomes dull and dark brown or blackish, especially on the under side. The body wall remains intact for a time, but soon becomes weakened at all of the articulations. Even with the most careful handling the appendages become detached and the body divisions fall apart (text-fig. 4). Within the body of the bee the softer tissues undergo rapid

Fig. 4. — Bees dead of septicemia dismembered by slight handling.

changes. The muscle tissues of the thorax lose their reddish brown color and become dull grayish white. The color then changes to a dull light brown, gradually deepens and finally becomes almost black. Meanwhile a gradual softening occurs. The remains of the muscle tissues become glue-

like and slightly ropy. After drying the body divisions appear hollow, the black scale-like remains of the tissues adhere closely to the inner surfaces of the body wall. Soon after death a characteristic disagreeable odor of bees dead of septicemia is present, the odor disappearing upon drying.

Pathogenesis.

Adult worker bees, queens and drones are suspectible to infection with *Bacillus apisepticus.* Workers and drones are attacked with equal readiness, but in inoculated colonies the queens were among the last of the bees to die of infection. Italian, Carniolian, black, and Italian-black hybrid worker bees were all equally susceptible. In inoculated colonies the brood was not attacked. The course of the disease is shorter at the optimum temperature for growth of the organism. Virulence of *Bacillus apisepticus* is not lost in culture. The death rate among bees inoculated with the tenth generation and after nine months in culture was as high as among those inoculated with the organism from the blood of bees recently dead of septicemia.

Immense numbers of *Bacillus apisepticus* within the digestive tract appear to cause no intestinal disturbance. Cages of from 60 to 80 bees consumed more than 10 c. c. of water with which the entire growth of an agar slant was mixed, with less than 10% infection resulting. Likewise, heavy suspension of the organism in the food composed of very dilute honey or sugar syrup usually causes less than 5% infection. If entrance to the blood is gained by way of the alimentary canal, this method of inoculation should result in the highest percentage of infection.

On the other hand, more than 90% of the bees in experimental cages frequently died of septicemia when they were inoculated by wetting immediately after they had gorged themselves with honey. The mere physical wetting of bees, whose alimentary canal contained an abundance of the inoculum, had no appreciable effect on the death rate.

Mode of Transmission.

The results of these experiments suggest strongly one conclusion regarding the portal of entry of *Bacillus apisepticus* to the blood of bees. Direct entrance of the organism through the exoskeleton is highly improbable. Experimental evidence indicates that it may enter at the spiracles and reach the blood through the walls of the tracheae, or tracheoles. In order that infection may occur the organism must be present in a wet condition. Whenever bees come in contact with water or wet substances in which the organism is present infection may result. The tendency for bees to become daubed when fed dilute food or water containing the organism might account for the small percentage of infection that occurred in the feeding tests. This indicates that wetting does not lower the resistance of bees to such an extent that entrance to the blood can be gained through the wall of the alimentary canal.

It is interesting at this point to note the experiments of White (5, 6) on cutworm and hornworm septicemia. Usually all inoculated hornworms were killed when *Bacillus sphingidis* White was placed directly in the blood by the puncture method. Less than 20% were killed when they were inoculated by feeding. Cutworms were not infected by feeding them *Bacillus*

noctuarum White, but when 37 silkworms were inoculated by feeding them leaves wet with an aqueous suspension of this organism, 24 of them died of septicemia.

The presence of *Bacillus apisepticus* in the soil has been demonstrated. Infection has resulted in three of four experiments when bees were moistened with water with which humus soil had been washed. In nature it would seem that bees might become infected whenever they came in contact with moist or wet soil or with water which is contaminated from the soil. The soil about the apiary, if moist and shaded, is especially apt to be infected from bees dead of septicemia. Although in experiments the disease was not transmitted within the hive, it would seem that this might be possible under extreme conditions of moisture, as sometimes exist in bee cellars or in colonies in early spring when the hives are not thoroughly cleaned of dead bees. In the Government apiary at Somerset, Maryland, and in other apiaries from which bees were received, the greatest number of infected bees were found in colonies on low shaded ground. Only an occasional infected bee could be found in colonies on higher soil exposed to direct sunlight for the greater part of the day.

Distribution of the Disease.

Samples of bees dead of septicemia have been received from all of the chief beekeeping sections of the United States. It may be assumed that it is present here wherever bees are kept. Nothing is definitely known concerning its distribution in other countries.

Treatment.

In a previous paper (2) it was stated that dryness, such as characterized sandy and well-drained apiary sites, exposed to direct sunlight, is not conducive to the spread of septicemia. With the additional facts at hand that have been determined concerning the causative organism and the method of infection, it would seem that providing dry conditions for the bees should limit infection to the minimum insofar at least as it occurs within the immediate vicinity of the apiary.

Summary

1. Septicemia is a disease of adult honeybees caused by *Bacillus apisepticus*, an actively motile organism found in the blood. It is estimated that the losses caused by this organism are less than those from American foulbrood, European foulbrood, or Nosema disease. Colonies may become weakened by septicemia, but it is seldom that a colony is destroyed.

2. Bacteria in the blood of adult bees were observed by Cheshire (3) and Bahr (1).

3. *Bacillus apisepticus* is readily cultured. It does not form spores, but remains viable over long periods in a wet environment. It is quickly killed by heating and by direct sunlight. There appear to be a number of strains of the organism.

4. Infection appears to occur by way of the trachea. Wetting bees with an aqueous suspension of *Bacillus apisepticus* often results in nearly a 100% infection. Infection usually results when a film of water contain-

ing the organism is spread over one or more spiracles on the thorax or abdomen. Twenty-five to thirty per cent of infection results when bees come in contact with the wet remains of bees recently dead of septicemia.

5. *Bacillus apisepticus* is found in the soil, and infection may occur when bees are wet with water with which infected soil has been washed.

6. Adult worker bees, queens and drones are susceptible, although queens appear to be more resistant than workers. The brood of bees is not attacked. The races of bees common to this country are not immune from septicemia.

7. In nature bees may become infected when they come in contact with wet soil or water that is contaminated from the soil.

8. Septicemia is widely distributed throughout the United States.

9. More infected bees were found in colonies on low humus soil shaded throughout the day than in colonies on sandy, well drained soil exposed to direct sunlight.

Literature.

1. Bahr, L. — 1922. Paratyphus der Honigbiene, in Archiv Bienenk., Vol. 4, pp. 177—213.
2. Burnside, C. E. — 1928. A septicemic condition of adult bees; in Journ. Econ. Ent., Vol. 21, no. 2, pp. 379—386.
3. Cheshire, E. R. — 1888. Bees and beekeeping, Vol. II, 652, pp. London.
4. Snodgrass, R. E. — 1925. — Anatomy and physiology of the honeybee; 327, pp. New York.
5. White, G. F. — 1923. Hornworm septicemia; in Journ. Agr. Research, Vol. 26, p. 477—486, illus.
6. id. — 1923. Cutworm septicemia; ibid. Vol. 26, pp. 487—496, illus.
7. Zander, Enoch. — 1909. Tierische Parasiten als Krankheitserreger bei der Biene; in Leipziger Bienenzeitung, Jahrg. 24, Heft 10, pp. 147—150; ibid., Heft 11, 164—166. (Also in Münchener Bienenzeitung, 1909, Heft 9).

Le Coléoptère du Colza (Entomoscelis adonidis Pall., Chrysom.) en Bulgarie.

P. Tchorbadjief, Sofia, Bulgarie.

(Avec 1 diagramme.)

Pendant les dernières années la culture du colza *(Brassica rapa oleifera* D. C.) en Bulgarie a pris une grande extension. Nos conditions de climat et de terrain, de même que le grand rendement de cette culture, favorisent cette extension. Cependant celle-ci est menacée de destruction par l'apparition en masse d'un coléoptère, *Entomoscelis adonidis* Pall., que la population locale nomme "Coléoptère du colza". Pendant l'année 1928 cet insecte est apparu en quantité tellement grande que la récolte eut été sérieusement compromise si des mesures n'avaient pas été prises à temps pour combattre le fléau.

A cette occasion des recherches furent faites et des résultats publiés par moi dans un article: „Le coléoptère du colza en Bulgarie" *). Je cite ici quelques details biologiques qui ont trait à cet ennemi et à la lutte entreprise contre lui en Bulgarie.

En automne 1927 la ponte fut observée du 15 octobre au 10 novembre: les femelles se rassamblaient par petits groupes dans les semis de colza. L'éclosion des oeufs eut lieu au printemps entre le 20 et le 30 mars. La destruction du colza par les larves commença, plus activement vers la fin de mars. Les larves vivent en groupes et se dispersent seulement à la fin de leur développement. Dans des condition favorables, le développement des larves est achevés en 19 à 22 jours. La première mue a lieu le 4e jour, la seconde 5 à 6 jours après la première, et la troisième après 7 à 9 jours. Trois ou quatre jours après la dernière mue, la larve s'enfonce dans le sol à 3—4 cm de profondeur et là confectionne son cocon de terre. Quatre ou cinq jours après, elle subit une nouvelle mue et se change en chrysalide (pupa libera). Après 3 semaines environ apparait l'imago, lequel s'observe dans les première jours du mois de mai. Vers la fin de ce mois les coléoptères se dispersent, s'enfonissent dans le sol, où pendant tout l'été ils dorment d'un someil léthargique. Dans la table ci-jointe, je résume les phases du developpement annuel du coléoptère.

---

*) Bull. de la Société entomologique bulgare, Vol. IV, pp. 65—90, Sofia, Bulgarie.

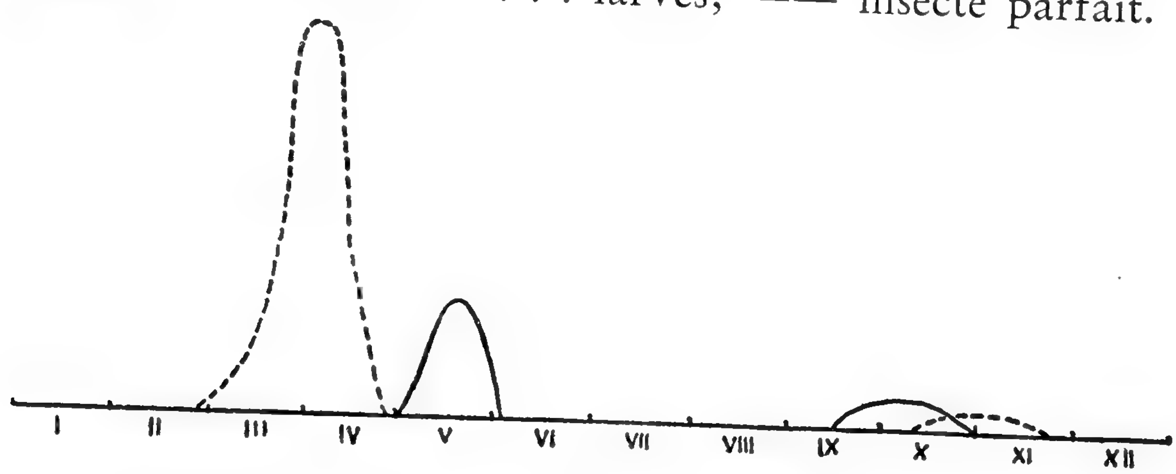
Tours	1 — 10	10 — 20	20 — 30
Janvier	• • • • • • —	• • • • • • —	• • • • • • —
Février	• • • • • • —	• • • • • • —	• • • • • — —
Mars	• • • • — — —	• • — — — — —	• — — — — — o
Avril	• — — — — o +	— — o o o o +	— o o o o + +
Mai	o + + + + + +	+ + + + + + +	+ + + + + + +
Juin Juillet Août	+ + + + + + +	+ + + + + + +	+ + + + + + +
Septembre	+ + + + + + +	+ + + + + + +	+ + + + + + + •
Octobre	+ + + + + • •	+ + + • • • •	+ • • • • • —
November Décembre	• • • • • • —	• • • • • • —	• • • • • • —

Le dévelopement du coléoptère du colza pendant l'année.
• oeuf, — larve, o chrysalide, + insecte parfait.

Je dois ajouter que malgré des recherches assidues, je ne suis pas parvenu à découvrir l'existence de parasites chez ce coléoptère.

La larve a aussi été observée sur les herbes suivantes: *Brassica napa oleifera* D. C., *Brassica rapa capitata* L., *Brassica rapa gongilodes* L., *Raphanus raphanistrum* L., *Lepidium draba* L., *Geranium pirenaicum* L., *Cirsium arvense* Scop., *Carduus acanthoides* L., *Sinapis nigra* L., *Sinapis arvensis* L., *Capsella boursa-pastoris* Mouch. et *Adonis vernalis* L. Le colza et la navette *(Brassica napa oleifera D. C)* sont les plantes préférées. Cependant les larves ne dédaignent pas à l'occasion le choux, la moutarde et le choux-rave. Le coléoptère attaque même les siliques du colza.

Le suivant graphique représente le dégât causé par *l'Entomoscelis adonidis* pendant une année: . . . . . larves; —— insecte parfait.



Jusqu'à présent le fléau en question n'a été combattu que par des moyens mécaniques, notamment en brûlant les nids de larves ou en les écrasant. Auparavant le cultivateur incapable de lutter contre ces insectes souvent abandonnait la culture du colza. Cette année on a employé, et avec succès, principalement des moyens chimiques: vert de Paris et arséniate de plomb.

Über den Laut-Apparat der Flöhe.

Professor Dr. Günther Enderlein, Zoologisches Museum der Universität Berlin.

(Mit 3 Textfiguren.)

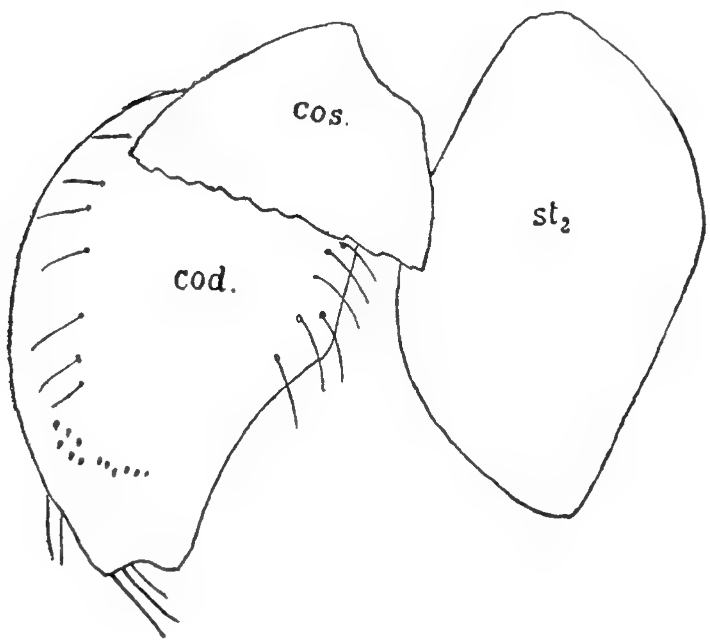
Bereits im Jahre 1901 *) machte ich auf ein eigentümliches Organ vieler Aphanipteren aufmerksam, das auf der Innenseite der Hintercoxen seinen Sitz hat und aus einer Anzahl winziger, kurzer und dicker Dörnchen besteht, die in etwa 1—2 Querreihen angeordnet sind. Dieses Organ ist beiden Geschlechtern, anscheinend mit geringen Modifikationen, eigen. Es wurden von mir, l. c., p. 555 in Fig. A bei *Pulex irritans* L. und in Fig. B bei *Pulex aequisetosus* Enderl. 1901 aus Togo abgebildet.

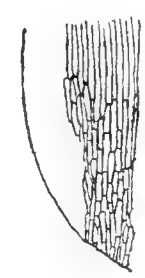
Damals hatte ich mir keinerlei Gedanken über die Bedeutung dieses Organs gemacht. Erst etwa 1—2 Jahre später beobachtete ich zufällig einen Menschenfloh, der ohne zu stechen auf meiner Hand saß, eigenartige Bewegungen machen. Er saß auf den vier vorderen Beinen, hob das Abdomen stark nach oben und bewegte seine Hinterbeine schnell und kräftig von unten nach oben hin und her. Ich erinnerte mich dabei sogleich der eigenartigen Organe der Innenseite der Coxen und der auffälligen Größe der ersten Bauchplatte und die Möglichkeit eines Stimmapparates zog ich in Betracht. Die Bewegung ist kräftig und besteht aus einem gleichzeitigen, gleichgerichteten, ruckweise Auf- und Niederbewegen der Hinterbeine, wobei die Schenkel, Schienen und Tarsen gespreizt und in gleichem Knie-Winkel spitzer als 90 Grad) immer die gleiche Lage zu einander behalten, die durch ihre Regelmäßigkeit in keiner Weise an eine Putzbewegung erinnert. Aus dieser Bewegungsart war ohne weiteres zu ersehen, daß der Schwerpunkt dieser Funktion in den Coxen lag; bei einer Putzbewegung würden jedoch die Schienen und Tarsen, die ja gerade mit guten Bürsten versehen sind, die abbürstenden Bewegungen übernommen haben, die ja bei allen Insekten so charakteristisch sind, daß eine Verwechselung damit nicht in Frage kommen kann. Ich untersuchte daraufhin die erste Bauchplatte (st. 2) näher und fand sie dicht mit feinen Riefen oder Leistchen besetzt, so daß damit ihre Bedeutung erwiesen war; es findet sich zwar auf dem ganzen Körper eine ähnliche Skulptur, die aber in keiner Weise die Schärfe der Ausbildung der des ersten Sternites erreicht; sie ist dort meist so fein, daß sie im Canadabalsampräparat meist kaum nachweisbar und nur an trockenen Stücken überhaupt leicht erkennbar ist. Aus ihr ist augenscheinlich die im Vergleich hierzu scharfe und tiefe Skulptur des Sternit II durch Differenzierung entstanden.

*) Enderlein, G. Zur Kenntnis der Flöhe und Sandflöhe. Neue und wenig bekannte Puliciden und Sarcopsylliden; in Zool. Jahrb., Abt. Syst. 14, pp. 549 bis 557, Taf. 34, 2 Textfig. (1901).

Um eine genauere Schilderung der Vorgänge bei den Lautbewegungen geben zu können, habe ich mit der Bekanntgebung gewartet, bis ich nochmals Beobachtungen anstellen konnte. Aber erst bei meinem diesjährigen Aufenhalte auf den Kanarischen Inseln, wo diese Plagegeister recht häufig sind, konnte ich dies ein zweites Mal beobachten und so sind 25 Jahre darüber vergangen.

Da bei derartigen kurzen und zufälligen Beobachtungen eine Lupe nicht zur Hand ist, kann ich auch keine weiteren Hinzufügungen zu meiner ersten Beobachtung geben, zumal auch meine Augen durch eingetretene Weitsichtigkeit nicht besser geworden sind; aber ich halte es doch für angebracht, nun diese Beobachtung bekannt zu machen.





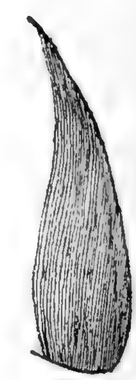


Fig. 1. *Pulex irritans* L. ♂. Hintercoxen und erstes Hinterleibssternit. cod. = rechte Hintercoxe mit dem Lautapparat; cos. = linke Hintercoxe, zum größten Teile entfernt; st 2 = erste Bauchplatte, als Resonanzboden. X 150.

Fig. 2. Desgleichen. — Riefung des vorderen Teiles des unteren Randes der ersten Bauchplatte. X 150.

Fig. 3. Desgleichen. — Riefung der hintern untern Ecke der ersten Bauchplatte. X 150.

Lautapparat.

1. Der Resonnanzboden. — Die erste Bauchplatte, vergleichend morphologisch Sternit II, ist ungewöhnlich groß, völlig unbehaart und von sehr feiner und sehr dichter Riefung oder ebensolchen Leisten besetzt. Diese Riefen sind in der hinteren Hälfte äußerst dicht, parallel und nicht durch Querstücke verbunden, wie Fig. 3 zeigt. Im unteren Vorderviertel ist diese Riefung etwas weniger dicht und nach hinten zu treten Querstücke dazwischen, so daß flachen Maschen entstehen (Fig. 2). Die Riefelung ist größtenteils etwas gebogen oder geschwungen.

2. Der Lautapparat der Hintercoxen. — Fig. 1 zeigt ihn von der Innenseite der Hintercoxen bei einem ♂. Das ♀ scheint Neigung zu mehr einreihiger Anordnung der Dörnchen aufzuweisen; jedoch finden sich häufig bei beiden Seiten des gleichen Exemplares erhebliche Verschiedenheiten. Bei den verschiedenen Aphanipteren ist er mannigfaltig variiert.

Die erzeugten Laute, für das menschliche Ohr unhörbar, dürften sonach, je nachdem welcher Teil der Bauchplatte von den Dörnchen bestrichen wird, in der Höhe variiert werden können.

Investigations of the Fauna of a Dying Tree.

Ivar Trägårdh, D. Sc., Chief Entomologist, R. Swedish Forest Experiment Station.

(With 9 text-figures.)

May I be permitted before I commence reading my paper to express my profound gratification that at this Congress, for the first time since International Entomological Congresses began, a special forest insect section has been instituted.

I venture to see in this an official acknowledgement not of the forest entomologists having achieved more than their brethren who are occupied in other fields, but of forest entomology being such an important and difficult branch that it is well to leave us alone to do some profound thinking on our intricate problems.

In this way it seems possible to further such a thorough discussion and threshing out of our questions as is in my opinion the most important feature of an International Congress, a feature which has not hitherto been so dominant as one would wish.

When I received the kind and flattering invitation of the secretary of the section, Mr. Glenn Herrick, to read a paper on forest entomology, I had to decide what I was going to speak about. Two lines presented themselves, either to speak on some special Swedish subject with which I was fairly intimate, but with the risk that there was perhaps comparatively little to learn for others, or to bring under discussion some problem of general interest, to which my own contribution was rather small, but which was in itself important enough to merit being brought under discussion.

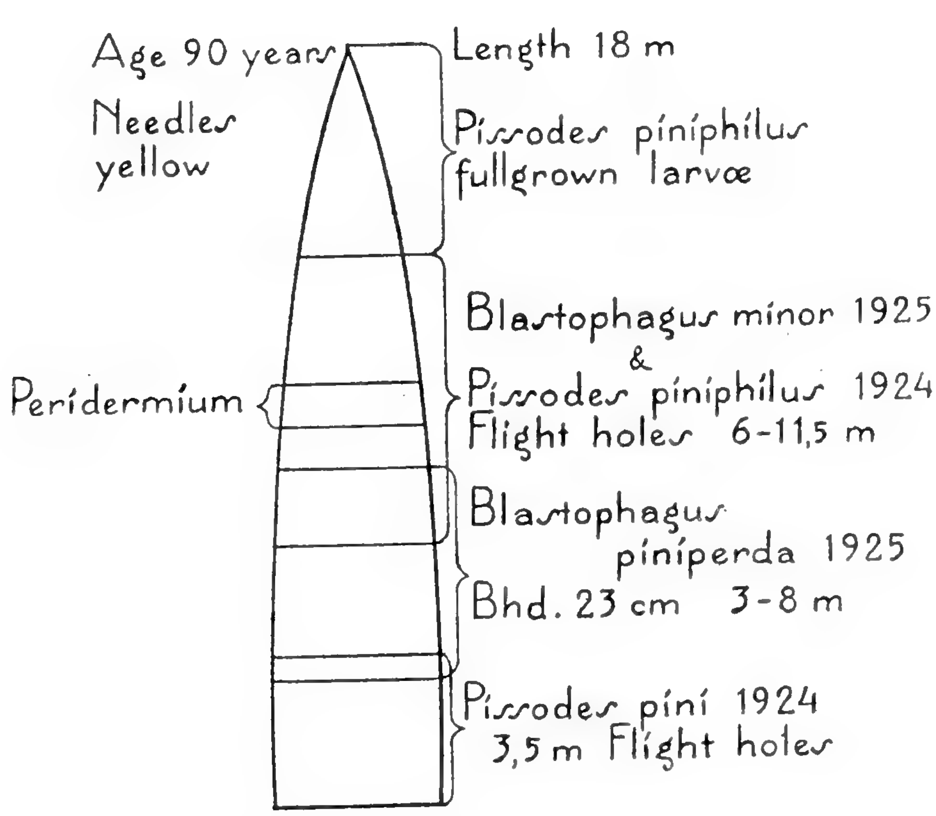


Fig. 1. — Analysis of dying pine-tree. Siljansfors, Sweden, Sept. 1, 1925.

I venture to think that the last course is the wisest and have therefore chosen as theme for my paper "Investigations of the Fauna of a Dying Tree". At the 3rd International Congress in Zürich I read a paper on "Some Methods of Research in Forest Entomology". One of these methods, the use of which I then suggested, was to analyse thoroughly the dying trees in order to obtain as complete a post mortem examination of them as possible, so as to enable one to study in which way their dying was brought about. The result of this analysis was then recorded graphically by using the diagram of a tree, in this instance of one belonging to the form-class value of 70, that is a tree where the diameter half-way between the top and the breast height is 70% of the breast height diameter.

This method has enabled me to define more clearly the different ways in which the insects succeed one another when attacking the trees and to get some inkling regarding the factors which determine the succession of them.

Moreover, this method which forces us, as it does, literally to examine every part of the tree, its limbs and twigs, has also born some important results from a faunistic point of view. As an instance of this may be mentioned that it was such an analysis that revealed the existence in Sweden of a bark-beetle new to science, a happening which may seem trivial to an American entomologist who is wont to find new species in his big continent perhaps every year, but is rather staggering in a country as old as Sweden, the bark-beetles of which already our great Linnaeus started exploring 150 years ago. When at the suggestion of Spessivtseff, my assistant, the Russian forest entomologists started analysing their dying coniferous trees in the same thorough manner

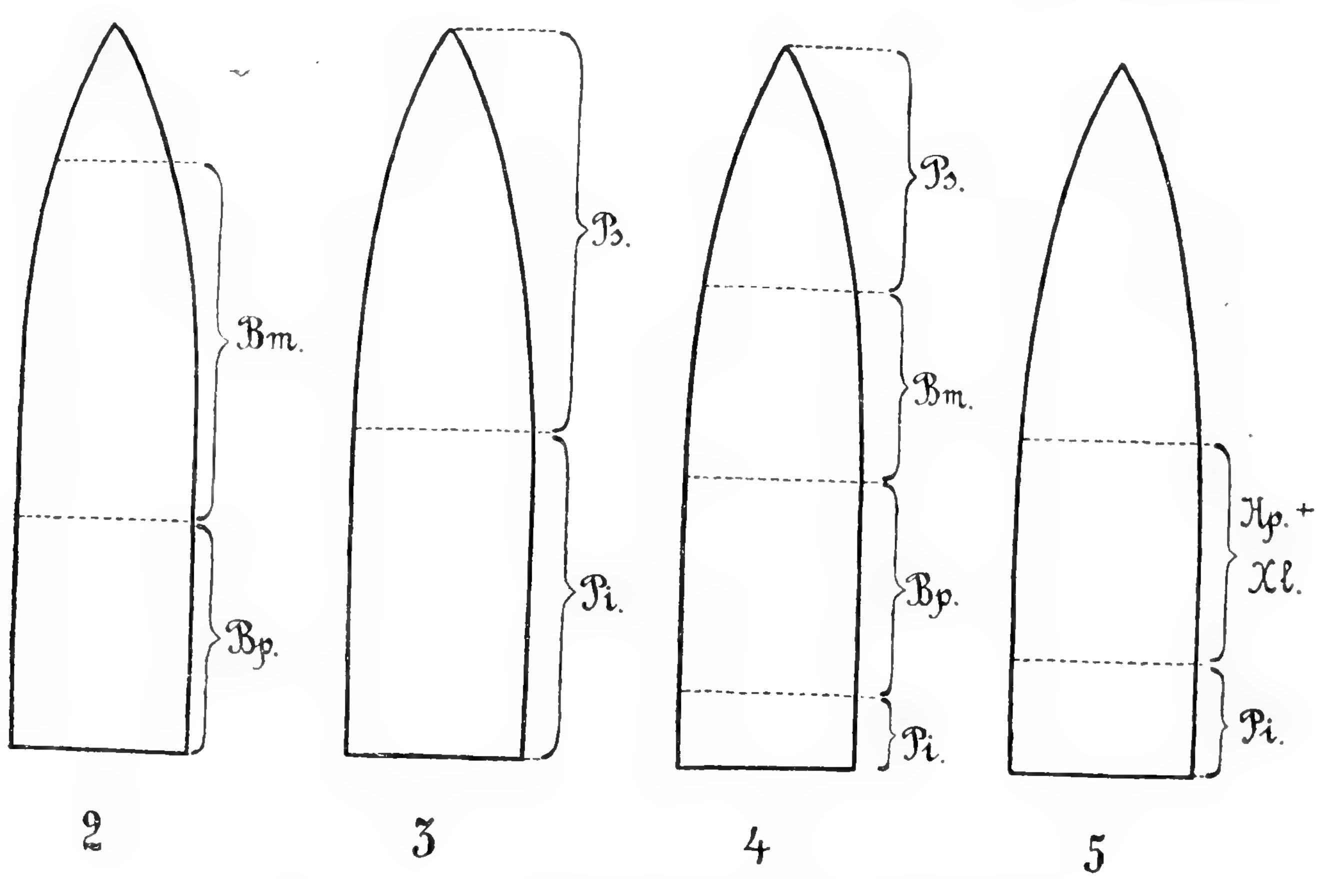


Fig. 2—5. — Diagrams of dying pine trees.

Bp = *Blastophagus piniperda;* Bm = *Bl. minor;* Pi = *Pissodes pini;* Ps = *P. piniphilus;* Hp = *Hylurgops palliatus;* Xl = *Xyloterus lineatus.*

as we do, of course they found this new species (by the way called *Pityophthorus trägårdhi* by the author Spessivtseff) all over European Russia, where it had previously been unnoticed.

If we analyze in this way in the spring a sufficient number of pine-trees which have either the new shoots poorly developed or show a slight discoloration of the needles — in both cases showing that their health is failing — we shall, in Sweden, find the following 4 distinct types of trees.

1. Almost clean cultures of *Blastophagus piniperda* and *Bl. minor*, accompanied by small *Pityophthorus* and *Pityogenes* in the crown (text-fig. 2).
2. Almost clean cultures of *Pissodes pini* and *P. piniphilus* (text-fig. 3).
3. *Pissodes pini*, small attack at the very base of the trunk, *Bl. piniperda, Bl. minor* and above them *Pissodes piniphilus* (text-fig. 4).
4. *Pissodes pini* at the base, *Hylurgops palliatus* and *Xyloterus lineatus* (text-fig. 5).

What is the meaning of this? When I first found *P. piniphilus* in the crown of trees which subsequently became attacked by the pine-beetles, the conclusion which immediately presented itself was that *P. piniphilus* was more primary than the others. Now I look upon the phenomenon in the following way. In those stands where the investigations have been carried out there is undoubtedly a gradual weakening of the trees going on throughout the vegetation period. As the insects here dealt with notably do not breed at the same time, but the pine-beetles *(Blastophagus)* start first, then comes *Hylurgops palliatus* and finally the two pine weevils *(Pissodes)*, I think this explains the different sequences observed. A tree sufficiently weakened at the end of June and the beginning of July will be attacked by the two pine-weevils to such an extent that in the following year there is no room for other insects where to breed (fig. 3). If the tree is healthy enough to withstand the attack of the greater pine-weevil *(P. pini)*, it will the next spring be attacked either by *Hylurgops palliatus*, nearly always accompanied by *Xyloterus lineatus* (fig. 5), or by the two pine-beetles (fig. 4) depending on the extent of injury done by the one-banded pine-weevil the year before or, if the tree is sufficiently weakened early in the spring, we shall find a clean culture of the two pine-beetles (fig. 2).

The gradual weakening of the trees and the fact that their enemies breed at different times of the season are therefore, in my opinion, the two fundamental facts which determine what kind of succession of insects will cause the death of the tree. And the way here adopted of recording the results of these summary analyses has led me to this possible solution of the problem.

Let us now see of what further use such summary analyses can be. The following two analyses (text-figs. 6 and 7), both from Gotska Sandön, a small island N. of Gotland in the Baltic Sea, illustrate two alternatives somewhat simplified, because *Blastophagus minor* did not occur on the trees analyzed and the two species of *Pissodes* mentioned above were replaced by *P. notatus*. The pine tree of which fig. 6 gives the analysis was weakened by a wandering sand-dune and showed a very extensive

attack by *Bl. piniperda* as high as 11 m, accompanied by an attack of *Orthotomicus longicollis,* which, by the way, is always associated with other bark-beetles, but lives exclusively in the bark. The extensive attack of *Bl. piniperda* is very interesting from a theoretical point of view, because it shows that, while this species, as we shall see later on, in the presence of *Bl. minor,* restricts its attack to the lower part of the trunk, it does so only because its further extension upwards is prevented by

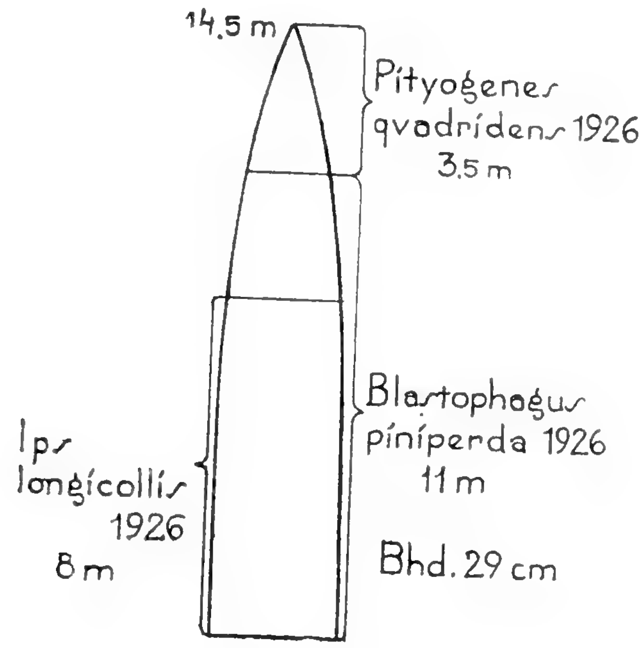


Fig. 6. — Analysis of dying pine-tree. Gotska Sandön, July 1926.

minor, not because it cannot breed under thin bark, thus illustrating the competition between the different species on the same food-plant. Such a pine tree, extensively infested by *Bl. piniperda,* dries rapidly and is then in the same summer in the crown attacked by *Pityogenes quadridens.*

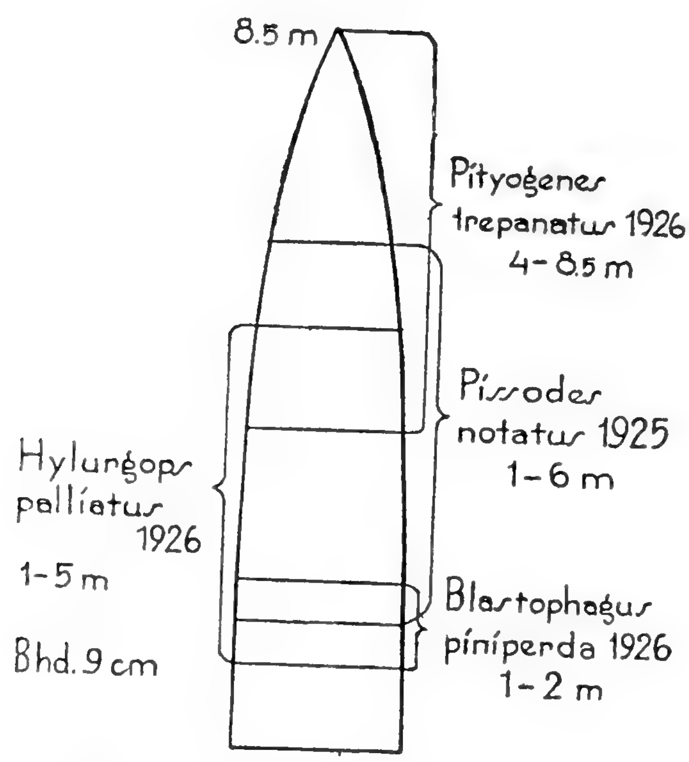


Fig. 7. — Analysis of dying pine tree. Gotska Sandön, July 1926.

But on Gotska Sandön another species of *Pityogenes* also occurs, *P. trepanatus,* which is very rare in other parts of Sweden. It is of interest, then, to see whether it is possible with the help of such analyses

to find out when *P. quadridens* occurs and when *P. trepanatus*. Text-fig. 7 shows the conditions existing when *P. trepanatus* breeds in the crown of the pine. In suppressed pines *Pissodes notatus* often breeds from 1—6 m. In such pine *Bl. piniperda* (to a very small extent) and *Hylurgops palliatus* breed the followed year, and in such more slowly killed and drier trees later on during the summer *P. trepanatus* appears, a species the breeding season of which occurs at least 4 weeks later than that of *P. quadridens*.

By means of such analyses we may be able to define more clearly the way in which the insects succeed one another when attacking the trees. As already pointed out (1926, p. 585) it has been possible in this way to account for an outbreak of *Blastophagus piniperda* and *minor* and to show that the original cause probably was a deficient amount of precipitation during a couple of years, followed by attacks in the crown by *Pissodes piniphilus*, and finally by attacks either of the pine beetles or of *Hylurgops palliatus*.

If a more detailed knowledge of the fauna of a dying tree is required, it is necessary to make still more thorough analyses. Saalas, who has probably made more analyses of trees than any other forest entomologist, has suggested (1919, p. 379) that 5 different degrees of infestation be adopted, which he calls I—V. This method is quite appropriate in so far as it reckons with the degree of infestation, viz. the area occupied by the different insects. But it is not illustrative and does not give the reader such a clear idea of the infestation in different parts of the tree as the diagrams suggested by Golovjanko, which method seems to be a further development of the methods employed by the author. Golovjanko cuts the tree to be investigated into 1 m sections, having previously marked the N, S, W, and E sides of the trunk. On each section the number of brood-galleries of each species is counted and the diameter measured. During the last two summers the author has made extensive use of this method in order to give it a trial. But I have at the same time always made summary diagrams of the type already discussed in order to ascertain the succession of different species. Curves illustrating the diameters and the thickness of the bark of the sections are incorporated amongst the other curves for the purpose of giving immediately an idea of the size of the analyzed tree. On the other hand, the number of brood-galleries occurring on the different sides of the trunk has not been counted, since there seems to be no well-defined difference between them in the localities where the investigations have been carried out by me. Whenever possible, the whole sections have been investigated, not just sample areas, as these are apt to give misleading data.

When calculating the brood-galleries, the pairing chambers of the polygamous species and the egg-tunnels of the monogamous ones have been counted. In the case of the wood-boring species the entrance holes have been counted, and in the case of species with only single larval tunnels, these have been counted. The numbers of the pine beetles and the pine weevils are therefore not strictly comparable, but this cannot be avoided, since one has to use the tree cut down for the purpose of making an analysis in the condition which it presents, which means that of some species there are pupal chambers present and of other species

egg-tunnels. Text-fig. 8 gives the first analyses obtained by this method. It gives a very good idea of how the different species divide the trunk between them and at the same time illustrates what a large number of insects are able to breed in a single tree of no great dimensions. The total number of brood-galleries of the two pine beetles amounts to nearly 900. Considering that the egg-gallery of the greater pine beetle may contain 100 eggs and that of the smaller one 50—60, it at once becomes evident, how imperative it is to cut down and remove the bark from the trees attacked. Even calculating the actual number of full-grown insects emerging from one egg-gallery to be only five, we still get a second generation of pine-beetles amounting to $5 \times 900 = 4,500$.

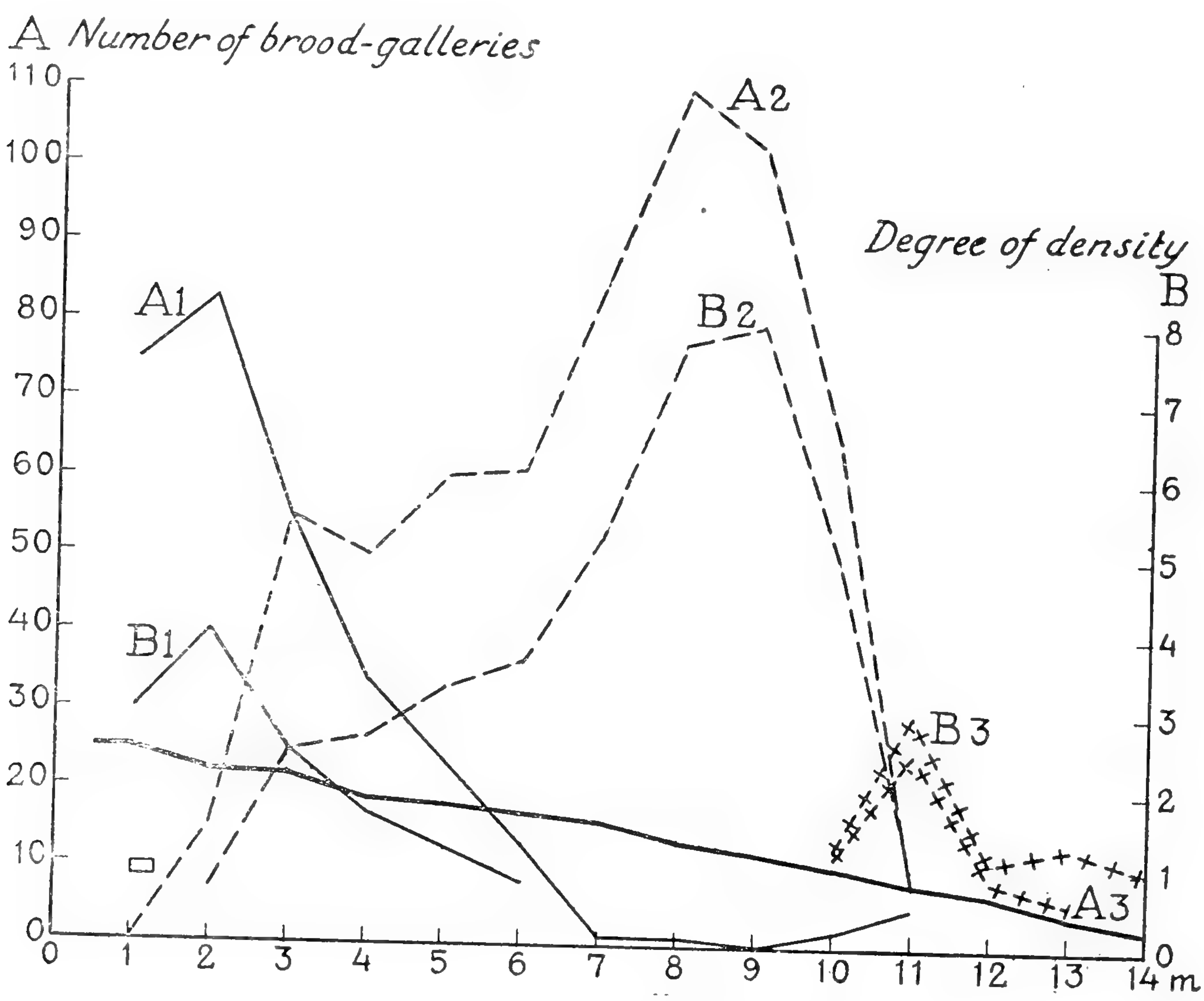


Fig. 8. — Analysis of a dying pine.

—— *Blastophagus piniperda*; - - - - *Bl. minor*; ++++ *Pissodes piniphilus*; —— Middle diameter of each section (cm); Small attack of *Pissodes pini*; A1—A3 Number of brood galleries; B1—B3 Degree of density.

The curves A, giving the absolute number of the brood-galleries, cannot be directly compared, because the trunk tapers gradually upwards, and as a result of this the number of brood-galleries must of a necessity diminish upwards when the whole area is covered by them. This error is eliminated by dividing the absolute number found on each section with the middle diameter of the section. In this way the d e n s i t y of infestation or average number per area is calculated. The curves B (fig. 8) give such an analysis illustrating the density of infestation of the different species.

We notice that when *Bl. minor* is present the density of *Bl. piniperda* rapidly decreases towards a height of 6 m and that it reaches its maxi-

mum lower down, at 2 m; *Bl. minor,* on the other hand, attains its greatest density at 8—9 m, further up it rapidly decreases, because that part of the trunk was occupied by the one-banded pine-weevil already one year earlier. That the density of *Bl. minor* is nearly twice that of *Bl. piniperda* is obviously due to the fact that the space occupied by the brood-galleries of the former is much smaller than that of the latter.

The next analysis (text-fig. 9) illustrates the part played by the size of the tree in the determining the fauna. On small trees the attack of the one-banded pine-weevil extends so far down the trunk that there is in the following year no room for *Bl. minor,* but only for *Bl. piniperda.*

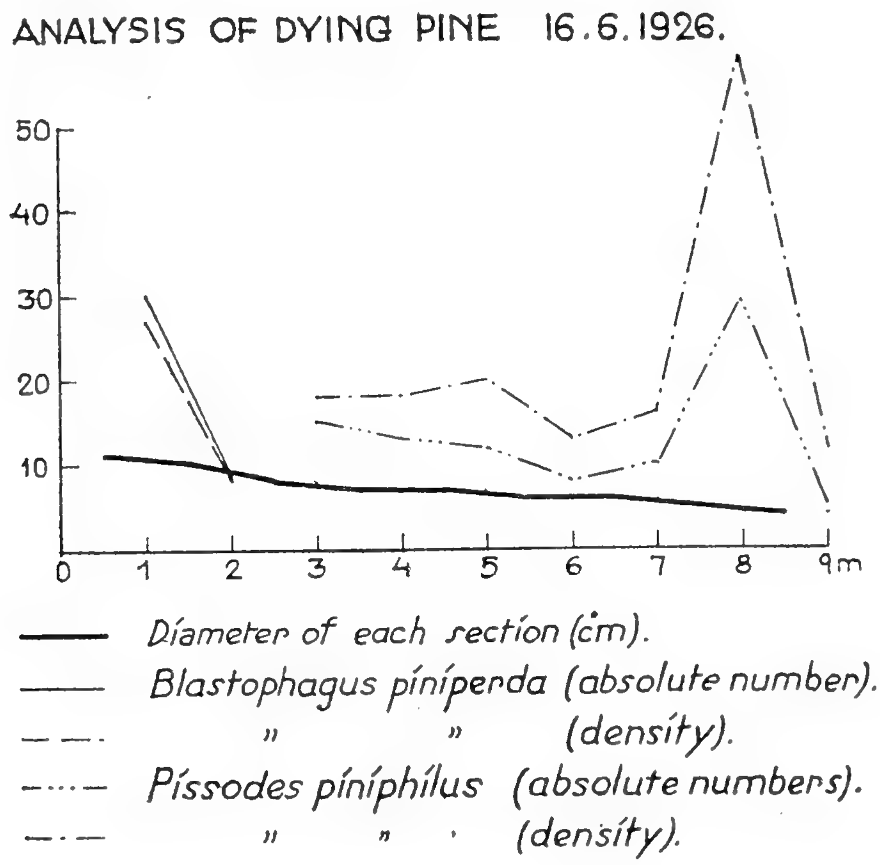


Fig. 9.

This method of recording the density of the attack of the different ısects whose accumulated efforts bring about the death of the tree brings light some features which seem to be of fundamental importance. irst the very characteristic feature that the denty of the attack of a certain insect is almost never ıe same in different parts of the trunk. For every ecies there is evidently a distinct part of the trunk which presents the ptimum conditions for ovipositing and possibly also for the development the brood. It follows from this that it is not possible to estimate the nber of the egg galleries of a certain species in a tree by only using e or two sample plots.

Another feature is also brought out by these disgrams, viz., the part played by the competition of the different insects in restricting the areas occupied by each one. When, for instance, *Bl. minor* is present, the attack *Bl. piniperda* on a 14 m high pine ceases at 6 m, but when, as on Gotska ndön, *minor* is absent, *Bl. piniperda* extends its attack on a tree of the ne size to 11 m.

The method may also prove useful, when it is desirable to follow the attack of a barkbeetle through its various phases. It must, however, be further developed and improved by including the parasites and the carnivorous insects in the investigation and by finding out the relation between the density of the attack and the size of the next brood and other factors, for instance the climatic factors and the humidity and temperature of the tree. I venture to think that the method developed and improved in this way may be of some use to those forest entomologists who are interested in the intricate phenomenon presented by a dying tree succumbing to the attack in the phloem by several species of insects.

Studies in the Fauna of the Soil in Swedish Forests.

Ivar Trägårdh, D. Sc., Chief Entomologist, R. Swedish Forest Experiment Station.

(With 10 text-figures.)

It is a characteristic trait of modern forestry to look into the ground in order to get at the fundamental principles governing the growth of the trees. This being the case, it is only natural that the entomologist should also endeavour to do his part in this difficult work and to explore the fauna of the soil.

During the last years I have devoted some time to this problem and I intend to-day to present some features of my work. Not because I can claim any important results, but rather because the problem is so intricate and important that there is an urgent necessity to discuss the methods and technique of the soil investigations as soon as possible, in order that uniform methods may be used the world over.

In several parts of the world efforts have been made to compute the number of invertebrates inhabiting a given type of soil. Notably at the famous Rothamsted Experiment Station in England some very important researches have been carried out, dealing with the fauna of arable land, manured and unmanured, and an estimation given of the number of individuals belonging to the different groupes found in a certain volume of that type of soil. In Germany Pillai and von Pfetten have investigated the fauna of the "Streudecke" (litter) in pine and spruce forests. Pillai used samples 1 square meter, but of different thickness from 2.5 to 8 cm, von Pfetten generally used samples of 3000 cm^3. In both instances the samples used are, in my opinion, altogether too big to allow such a detailed analysis as is necessary. The quantities of nematods, mites, and collembola were, as a matter of fact, too great to be even counted.

My own method has been to use automatic apparatuses based on the fact that the soil invertebrates are very susceptible to evaporation and strong light and automatically wander downwards in order to find a suitable degree of humidity and darkness. The generally used way to hasten this phenomenon is to heat the material to be investigated, either by surrounding the funnel in which the insects are to fall down by water (Berlese) or to suspend an electric bulb above the material (Tullgren). For my own part I have used the common warm-water funnel employed by chemists when filtering collodial matter and covered this with sieves with different sized mesh, according to the material used. As a rule no heat was employed, because if the moss or litter dries too quickly, the smallest acarina are apt to die before they have had time to crawl down through the sieve, and to adhere to the moss or to the dry leaves. It requires of course a somewhat longer time to get all the arthropods out of

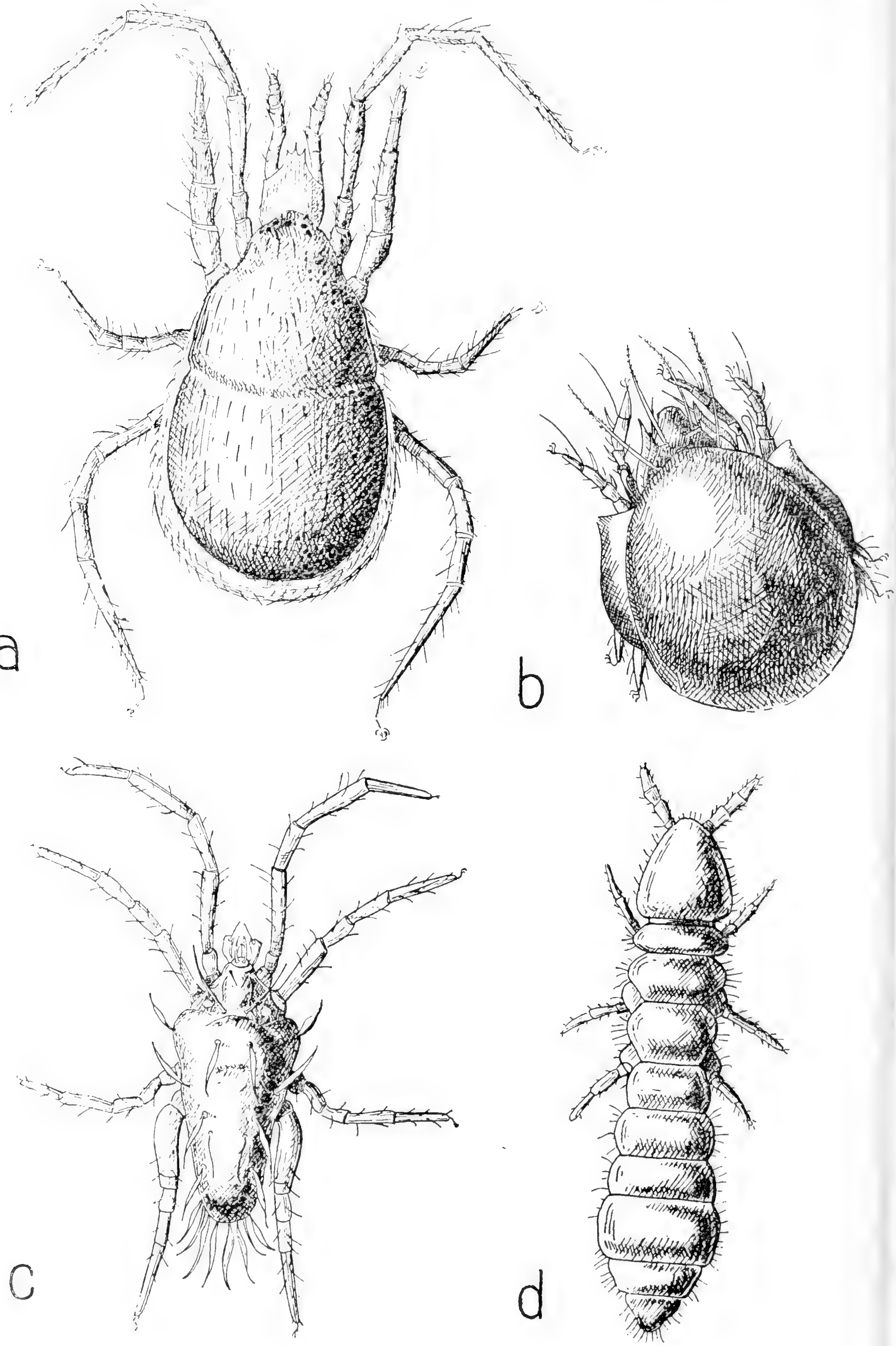


Fig. 1. — Representatives of the fauna of the soil.
a. *Gamasidae.* b. *Oribatidae.* c. *Trombidiidae.* d. *Collembola.*

the moss, but this delay might be compensated by using a greater number of funnels. Moreover, the slower treatment has some advantages in enabling us to count the organisms directly as they fall down in the glass-cups with alcohol put underneath the funnel and to tabulate the material in the chief groups, as well as to study the velocity of reaction to light and drought displayed by the different species.

The amount of material used seldom exceeded 200 grammes. This was necessary, because we are only two entomologists at the Forest Experiment Station and must therefore employ labour-saving methods as much as possible, until the investigations will have progressed so far that we have a firm ground on which to tread, in which case I hope that the government may feel inclined to increase my staff. In this way, by using small but numerous samples, it is possible to count all the specimens and even determinate them. Especially in regions where the fauna of the soil is poor in larger invertebrates, with more roving habits, one is sure to get all those species which are fairly numerous, which is the main point.

My method, then, differs somewhat from those used at Rothamsted, where the number of insects is referred to the volume of the soil samples. This is not feasible when dealing with lichens, moss, and decayed leaves, etc., where the same volume may contain very different quantities of organic and inorganic matter.

When dealing with material collected in this way, it is obviously not sufficient to count the number of species and specimens. Account must also be taken of their different size, which is vastly varying, many species measuring only 0.2 mm in length, while others are perhaps 10 mm long, which may mean that the volume of one specimen equals the volume of many others.

During the investigations hitherto made, which are only of a preliminary character, I have distinguished between the real Microarthropods, comprising Mites and smaller Collembola, and other arthropods which as a rule are of considerably larger size and comprise larvae of Coleoptera, Lepidoptera and Diptera, Coccidae, wingless Hymenoptera, Hemiptera, Spiders, Myriapods and Vermes. From the results obtained it will seem that this distinction is rather essential and enables us to draw some conclusions of a general character.

First some words about the mites (Acarina) which form such an essential part of the fauna of the forest soil and are represented by more species than all the other groups put together. The chief groups of them are the *Oribatidae* (Cryptostigmata) (text-fig 1b), the *Gamasidae* (Mesostigmata) (text-fig. 1a), and the *Trombidiidae* (Prostigmata) (text-fig. 1c), which have very different feeding habits. The *Oribatidae* are, as far as is known, all herbivorous, their food consisting of moss, lichens, and fungi. The *Gamasidae*, on the other hand, are mostly carnivorous, although amongst the *Uropodidae* there are probably many herbivorous forms. The *Trombidiidae* have widely different habits. Some, as for instance the *Bdellidae*, *Trombidiidae*, *Eupodidae* (c, fig. 1) and *Erythraeidae* are undoubtly carnivorous, but others are herbivorous, f. inst. *Bryobia*. Our knowledge of the feeding habits of the acarina is, however, on the whole as yet very insufficient. For this reason it is not possible to

divide them with any certainty into groups according to their habits, but we will have to use their systematic units in the following discussion.

The influence of the feeding habits on the distribution of the acarina is beautifully illustrated by the investigation on the acari of the mountain Sarek-tjåkko in arctic Lappland which I published 18 years ago. Above the tree region there are in the Lappland mountains three zones, one above the other, called resp. Birch-zone, Willow-zone, and Lichen-zone (text-fig. 2). In these zones the number of species of *Oribatidae* decreased from 19 to 15 and 8, that of Prostigmata from 15 to 7 and 8, but that of the Mesostigmata from 15 to 11, resp. 3. The herbivorous species, subsisting as they do on moss and lichen, occur up to the greatest altitudes, whereas the carnivorous Mesostigmata decrease very rapidly in num-

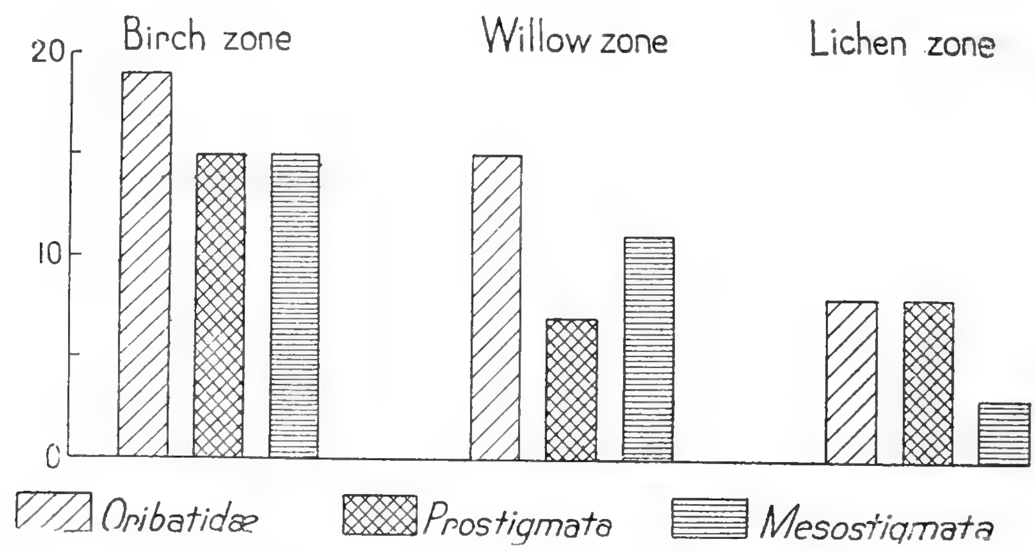


Fig. 2. — Distribution of the acarina in the Sarek Mts., Sweden.

ber of species and specimens, the obvious reasons for this being that there is not food enough for them in the lichen region. Some indirect information concerning the optimum conditions of these groups may also be obtained by investigating the fauna in regions presenting very distinct differences in this respect. Fortunately, during my preeconomic days as an entomologist at the University of Upsala, I had the opportunity of investigating the acarid-fauna of three very different regions, viz. from Egypt and the Soudan, where I travelled in 1901 during the dry season, from the French

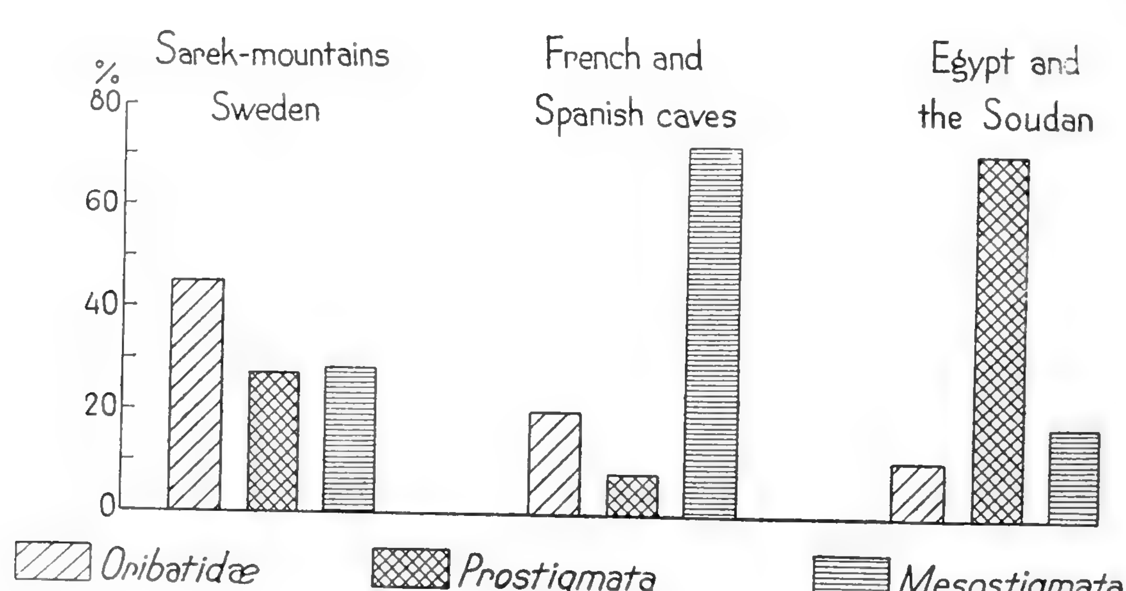


Fig. 3. — Composition of the acarine fauna of the Sarek Mts., French and Spanish caves, Egypt and the Soudan.

and Spanish Caves, where the French zoologists have made extensive collections of the subterraneous fauna and entrusted the acarina to me, and from the above-mentioned Sarek Mountains investigations in 1903 and 1907. These localities represent three very divergent types, one exceedingly hot and dry and with strong light, the other dark and damp, and the third with strong light but rather moist air and not of so extreme a type as the other two localities. We notice that only in the caves the *Gamasidae* are very numerous, in the other two localities they do not play any important

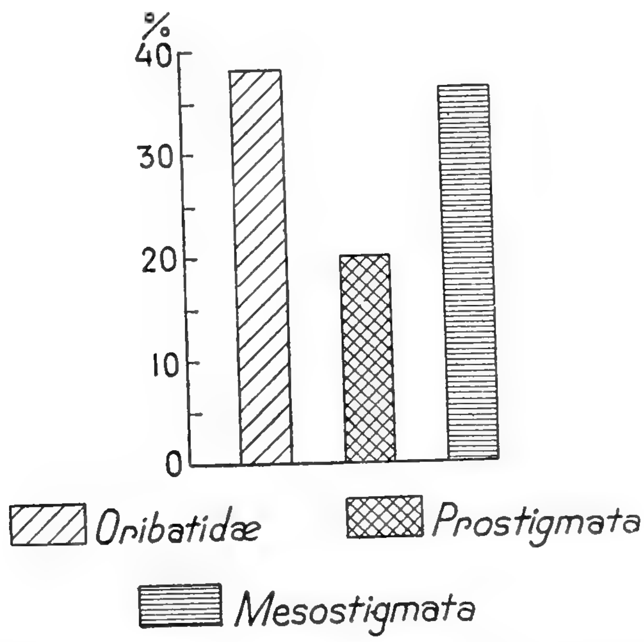


Fig. 4. — Composition of the acarine fauna of Switzerland according to J. Schweitzer.

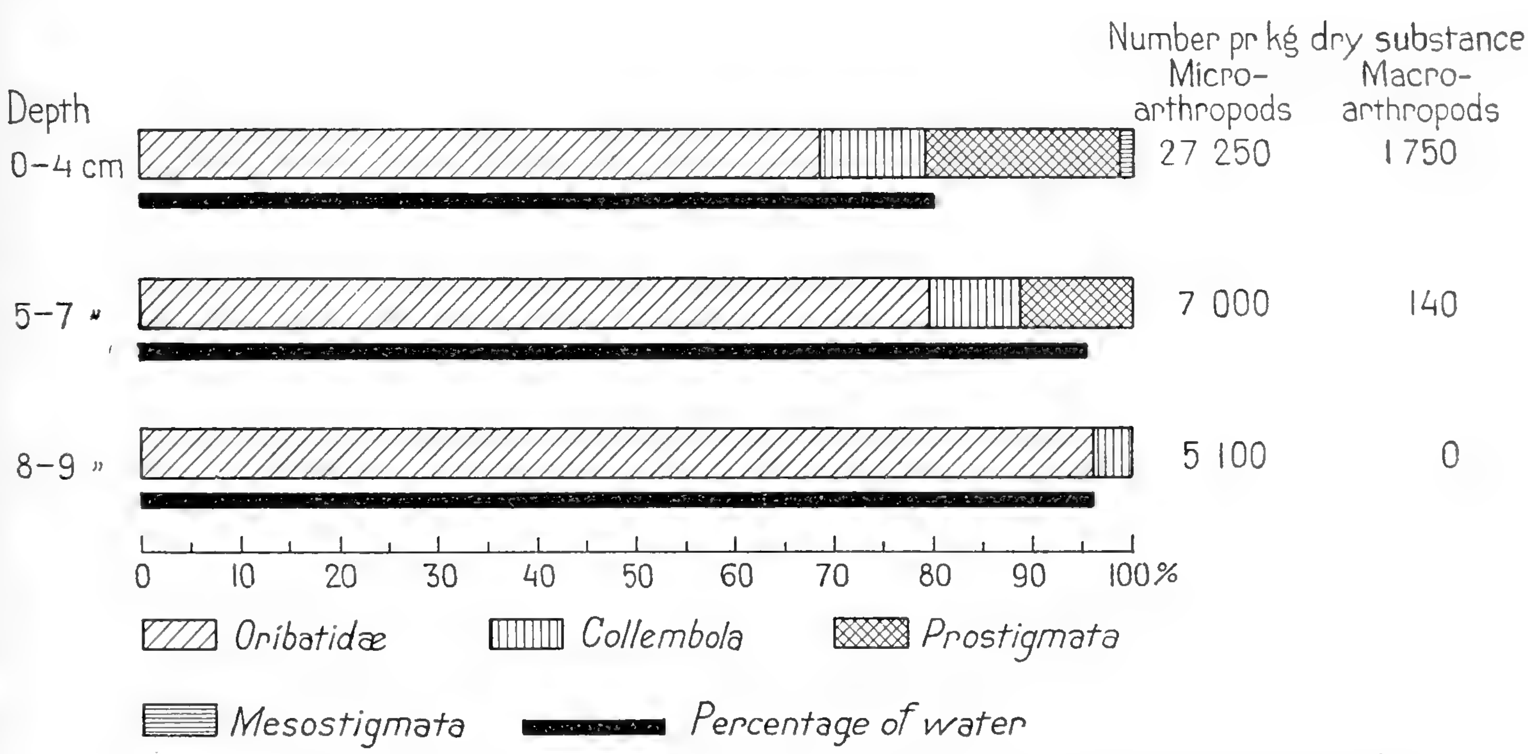


Fig. 5. — Analysis of the fauna of *Sphagnum*. Kulbacksliden, N. Sweden.

part. This is a good illustration of how susceptible the *Gamasidae* are against evaporation. The Prostigmata on the other hand, or at least many of them, occur abundantly even in the desert and are obviously far more protected against evaporation and even direct isolation than the *Gamasidae,* partly owing to their thick clothing of hairs and bristles and their bright colours. They are therefore the dominant group in Egypt and the Soudan. The Oribatidae are, as is well known through the marvellous investigations of A. D. Michael in England, exceedingly sensitive

against strong light and evaporation, but are able, thanks to their thick cuticle, to run about without cover when the air is fairly moist. It is therefore not astonishing to find that they are the most important group in the Sarek Mountains.

It is interesting in this connection to find that the acarine fauna of Switzerland, which is very well known through J. Schweizer's investigations, agrees fairly closely with that of the Sarek Mts., although the carniverous Mesostigmata are more numerous in Switzerland, which may be expected, since the survey comprises areas at all levels above the sea.

Let us after this return to the Swedish forest soil and start the examination of some uniform material such as the moss *Sphagnum* down to a depth of 9 cm. Text-fig. 5 gives the result of the investigation.

The difference between the 3 layers is mainly that the upper layer consists of living green moss and living not yet decayed leaves of plants, while the lower ones are dead stratified moss and that the upper layer contains less water and more oxygene than the lower ones.

Table I. — Contents of the three *Sphagnum*-layers.

I.	a) Living plants:	*Sphagnum angustifolium* (plentiful) leaves of *Rubus chamaemorus* leaves of *Oxycoccus microcarpus* needles of pine-tree (scarce)
	b) Dead plant-rests:	leaves of *Betula, Rubus chamaemorus* *Eriophorum vaginatum* (scarce) needles of pine-tree (scarce)
II.	Dead plant-rests:	*Sphagnum angustifolium* (plentiful) *Rubus chamaemorus* (single pieces of stems) *Oxycoccus microcarpus* (single piece of stems) *Eriophorum vaginatum* (single pieces of stems)
III.	Dead plant-rests:	basal parts of *Sphagnum angustifolium* (plentiful) basal parts of *Eriophorum vaginatum* (single) fruits of *Drosera rotundifolia* (single)

Table II. — Contents of the three *Polytrichum*-layers.

I.	a) Living plants:	*Polytrichum commune* (plentiful) *Sphagnum girgensohni* (plentiful) *Hylocomium parietinum* (scarce) *Vaccinium myrtillus* (scarce) *Vaccinium vitis-idaea* (scarce) *Carex globularis* (scarce)
	b) Dead plant-rests:	needles of spruce (scarce)
II.	a) Living plants:	basal parts of *Polytrichum commune* (plentiful) *Sphagnum girgensohni* (sporadic) *Hylocomium parietinum* (scarce)
	b) Dead plant-rests:	needles of spruce (scarce)
III.	Living plants:	basal parts of *Polytrichum commune*

Table III. — Contents of the three layers under a Willow.

I. Dry leaves of: *Salix caprea* (plentiful)
Betula pubescens
Betula verrucosa
Dryopteris linneana

II. Upper raw-humus layer and dead plant-rests, numerous hyphae of fungi.

III. Much decayed leaves of: *Salix caprea*
Betula pubescens
Betula verrucosa
roots of: *Vaccinium vitis-idaea*
dry twigs and pieces of wood.

III. Lower raw-humus layer, containing numerous roots and dry twigs of *Vaccinium* and pine.

We notice how poor this moss is in insect larvae and Collembola.

1) The number of Macroarthropods in the upper layer seems fairly large, but in this instance the figure is in a certain sense misleading, the insects being only very small Dipterous larvae, feeding on the moss and probably of very little importance in breaking down organic matter. Their number rapidly decreases in the 2nd layer and in the nethermost one none are present. We also notice:

2) what an important part the *Oribatidae* play in the population, especially in the lower layers;

3) how insignificant the *Gamasidae* are, being only present (1.5 %) in the upper layer, which seems to signify that the hard-shelled *Oribatidae* are not a suitable prey for these carnivora;

4) that the number of insects decreases rapidly downwards and below 1 dm there were no Arthropods in this locality;

5) the complete absence of any vermes.

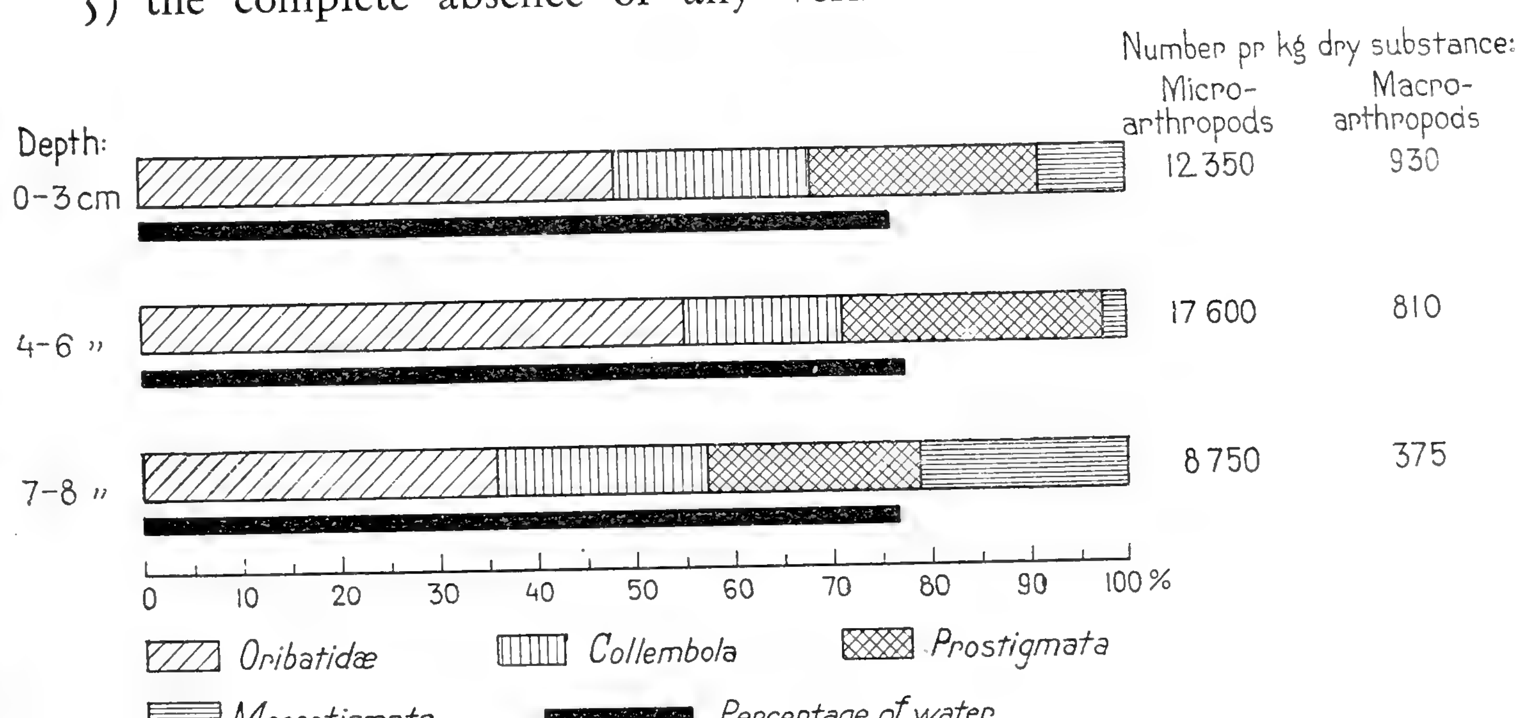


Fig. 6. — Analysis of the fauna of *Polytrichum*. Kulbäcksliden, N. Sweden.

These features are, no doubt, explained by the very unfavourable conditions present in the lower layers of the moss, owing to the great amount

of water and the absence of oxygen. Some *Oribatidae* are, however, typical for wet *Sphagnum*.

The next analysis (text-fig. 6), of *Polytrichum commune* from a dense spruce forest, shows quite different conditions. Three layers have been examined, the upper consisting of the living green parts of the moss, the next consisting of the brown basal parts of *Polytrichum commune* and dead parts of mosses, the nethermost consisting only of the basal parts of *P. commune*. The amount of water in the 3 layers is practically the same, about 75 %, as is also the content of organic matter. In this sample consisting of a moss growing in rather dry localities, the upper part of the moss is evidently not the one best suited to the organisms, but the middle layer, which presumably offers more ideal conditions as to sufficient content of moisture and absence of too strong light. We notice that the *Oribatidae* in this instance attain their maximum density in layer II and that the *Gamasidae* are most common in layer III. The relatively great frequency of Prostigmata in all the three samples is due to the presence in great numbers of a single species of *Alichus*, which evidently is a specialist on *Polytrichum*. The insects in these samples consist of some wingless *Hymenoptera*. Spiders, small larvae of *Diptera*, and larvae of *Coccidae*, although their number pro kg dry material is fairly high, hardly play any important part in breaking down organic material. No vermes were present.

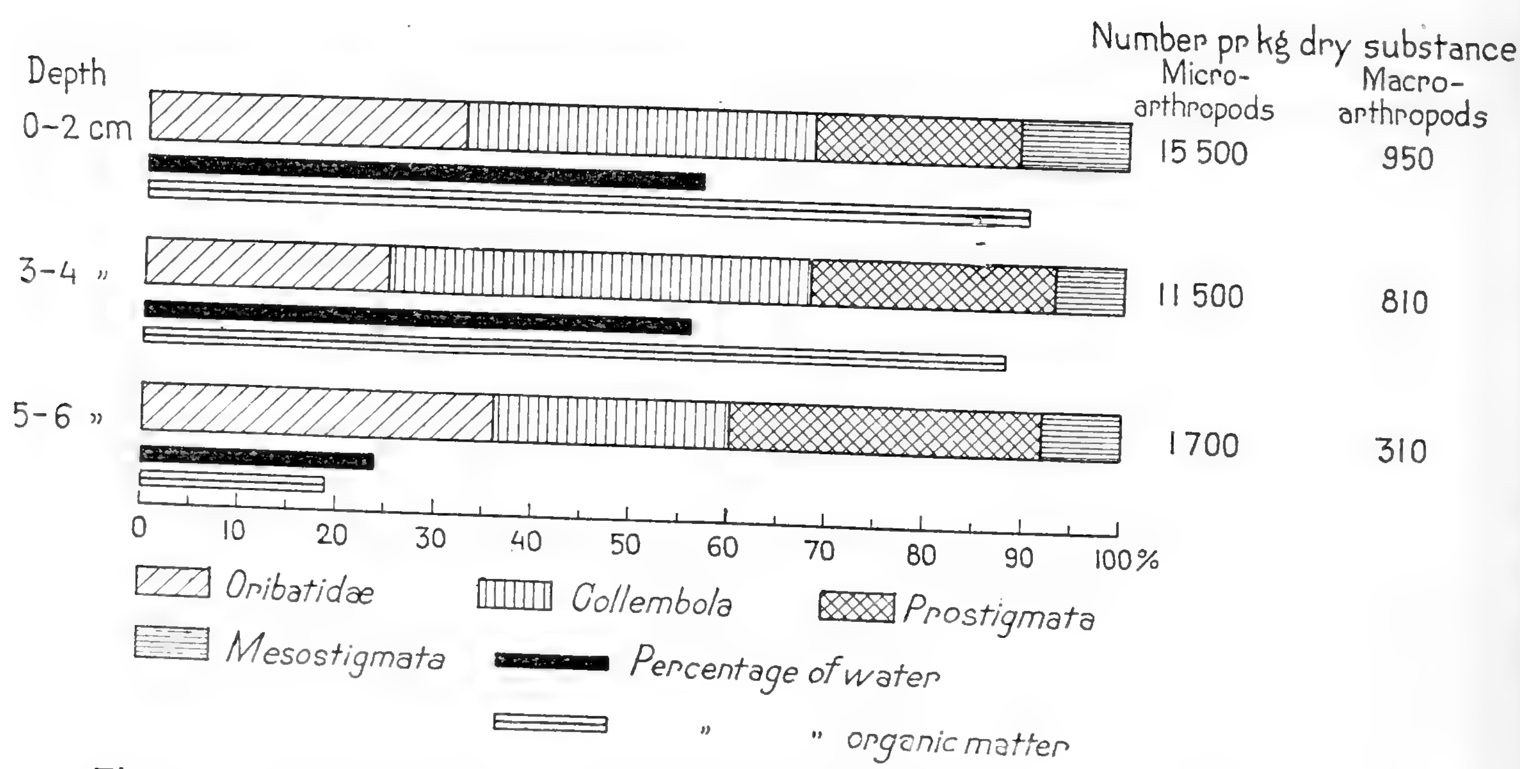


Fig. 7. — Analysis of the fauna of dry leaves. Kulbäcksliden, N. Sweden.

We now proceed to analyse samples from a locality where the breaking down of organic matter may be supposed to be more vigorous than in the two previous samples, viz. the layers of dry, more or less decayed, leaves under a willow; text-fig. 7 illustrates the results of this analysis. We notice the following features:

1) The *Oribatidae*, the dominance of which was so characteristic in the previous samples of moss, are no longer the most numerous group.

2) Their part as leading group has been taken over by the *Collembola* in the 2 upper layers.

These two facts illustrate what we already knew: a) that the chief food of many *Oribatidae* is moss and lichen, b) that the *Collembola* feed largely on fungi, etc., which are present on the decaying leaves.

3) The number of insects (including this time larger *Collembola)* does not seem very great as compared with the figures from *Polytrichum.* But if we examine what insects are present, for instance in the upper layer, the difference is very striking. In this layer we find the following insects: 4 Spiders, 2 *Staphylinidae,* 2 *Chrysomela,* 1 beetle larva *(Cantharis),* 2 Cockroaches, 1 Lepidopterous larva, 2 Hemiptera, 4 *Coccidae,* 1 Dipterous larva, 1 Myriopod, and 1 Snail.

If we measured the volume of these forms, we should, however, have to correct the figures by at least doubling them as compared with those from *Polytrichum.*

In these layers of more or less decayed leaves, the number of Microarthropods decreases rapidly downwards, much more so than the number of Macroarthropods, and more than in the samples discussed previously. This feature is explained if we analyse the percentage of organic matter in the three layers. The figures are I 90%, II 88%, III 19%. If we refer the number of Macro- and Microarthropods to 1 kg of organic matter we find that the Macros increase in number from the 2nd to the 3rd layer, whereas the Micros decrease successively downwards, but not at all in the same proportion as the organic matter. It is not possible to say what this means. But one many hazard the guess that the figures indicate that the Macroarthropods are not so stationary in their habits as the Microarthropods and that, perhaps during the heat of the day, they wander downwards into the deeper layers and that an analysis made during the night may give other results. At all events, it is necessary to investigate the wanderings of the animals in the soil, and ascertain how far they influence the results of the analyses.

It may here also be pointed out that it is not enough to know the percentage of organic matter in the different layers. We must also know the condition of the organic matter from the point of view of the amount of nutrition and of space it offers to the organisms. Especially the mosses presumably offer the organisms widely different conditions according to their different structure.

Before I proceed to discuss the conditions which seem to favour the frequency of insects in the soil, I will refer to the results of the analysis of two layers of beech-leaves in the South of Sweden in order to illustrate how even very slightly more detailed analyses than those described above will throw light on features otherwise hard to explain.

We notice 1) that the number of *Oribatidae* is rather small in the upper layer, but increases enormously in the subjacent layer, whereas the number of *Collembola* decreases from 54.4 to 7%. This does not seem to fit at all with what I have just stated with reference to the willow leaves. If however we examine the *Oribatidae,* we find that we can divide them

into 3 groups (text-fig. 9) a) full grown *Oribatidae* of a size not under ca. 0.6 mm, b) very small adult *Oribatidae* belonging to the genus *Damaeosoma* or allied genera, (d) not exceeding 0.3 mm, c) larvae and nymphae of *Oribatidae* (n).

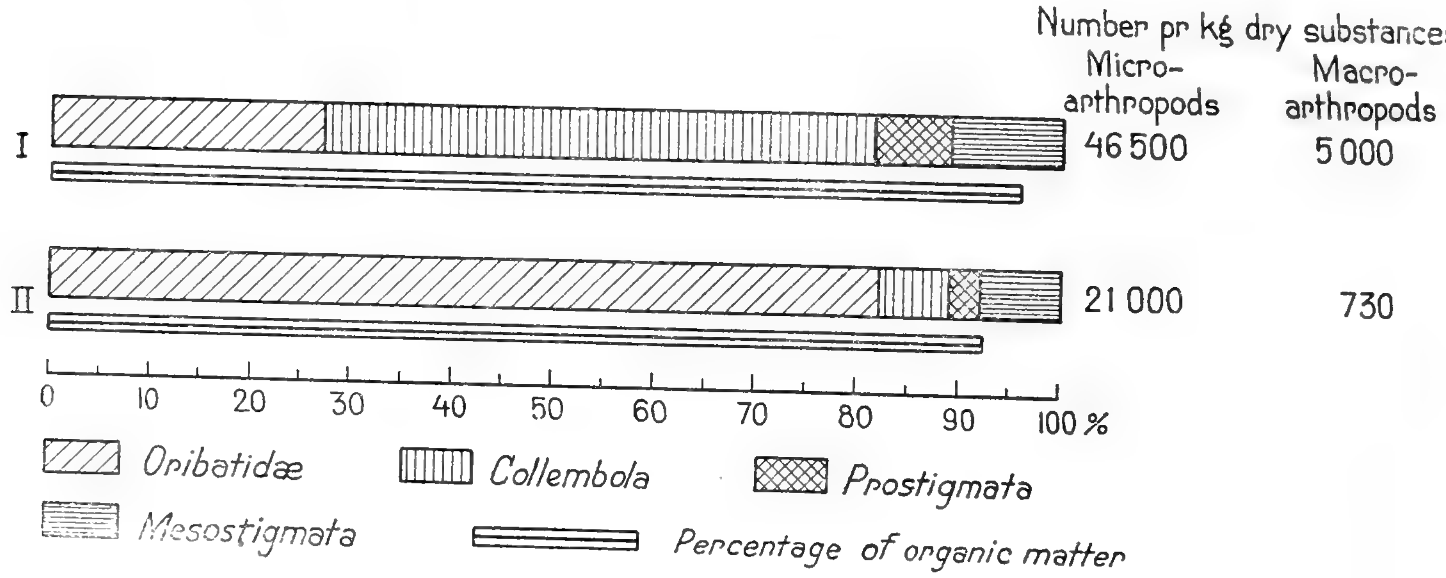


Fig. 8. — Analysis of two layers of dry, more or less decayed, beech-leaves. Simlängsdalen, S. Sweden.

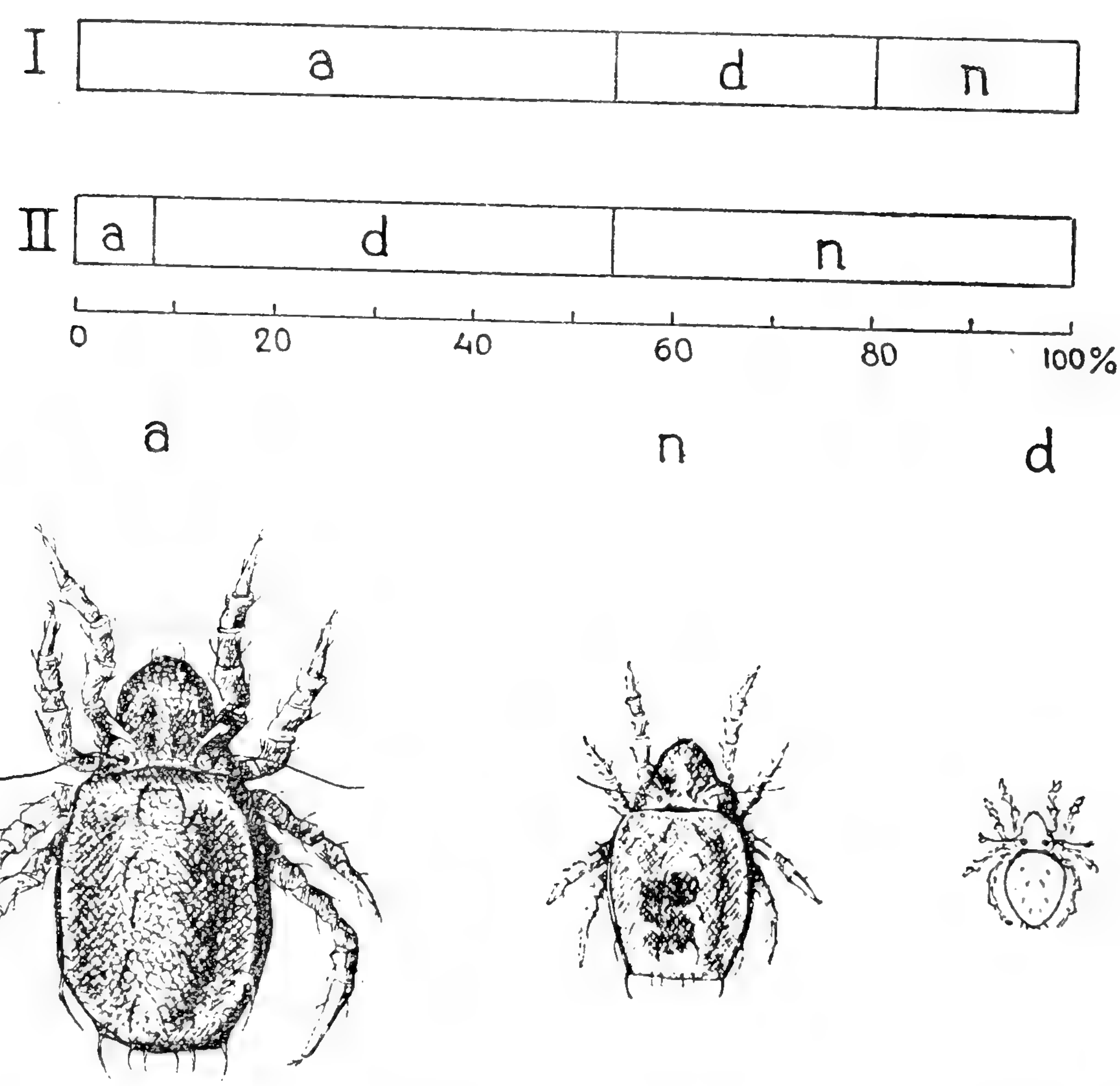


Fig. 9. — Analysis of the *Oribatidae* of the two layers of decayed beech-leaves. Simlängsdalen, S. Sweden.

We perceive that the numerical dominance of the *Oribatidae* in the lower layer is due chiefly to the great number of *Damaeosoma* and nymphae. That is to say that the nursery is situated in the ground floor, or rather the cellar, where also the dwarf species live which are most susceptible to evaporation.

In this instance the figures ought to be corrected by calculating the volume of the different *Oribatidae*. The number of Macroarthropods is here very great, in the upper layer no less than 5,000 pro kg dry substance and here for the first time we also find vermes, whose importance as soil improvers is so well known.

Leaving aside the question of the role played by the smaller *Collembola* and the mites, we now finally turn our attention towards the factors which determine the frequency of the macroarthropods.

The following table illustrates this. We notice, how exceedingly poor the fauna of the litter of dry spruce and pine needles is, if formed by needles already dry when they fall to the ground. The figure 80 in sample 4 represents straying ants which happened to wander across when the sample was taken. As soon as the ground is covered by leaves the fauna becomes 70 times as rich even in the far North, and in the South of Sweden still richer.

Tab. IV. Number of Macroarthropods pro kg dry substance.

1. Dry more or less decayed beech-leaves in the South of Sweden . . .	5,000
2. Dry, more or less decayed willow-leaves in the North of Sweden . . .	950
3. Dry spruce-needles at the base of a spruce	13
4. Dry pine-needles and a little moss	80*)
5. Moss *Hylocomium proliferum* and *H. parietinum* under spruce-boughs on a cutting	830
6. *Hylocomium parietinum*	17

But even needles may promote a rich fauna of Macroarthropods, if they are not dry when they reach the ground, as was the case in samples no. 3 and 4, but are green as they are when boughs are left on cuttings. In the latter instance we find in the moss under the boughs a rich insect life, almost as rich as when leaves cover the ground. In the latter instance (no. 5, tab. IV) the needles decay on the ground, which involves the presence of numerous fungi and saprofytic insects and their train of followers.

The investigation here related amply support the generally accepted opinion that the condition of the forest soil is improved when the coniferous and foliiferous trees are mixed and that the manuring of the forest, found to take place when boughs and twigs are left on the ground, is at least partly explained by the favourable influence due to the fauna.

The summary I have given here of my investigations of the fauna of the forest soil in Sweden has of necessity been short and sketchy. There are so many intricate problems to be solved before we can pass from the preliminary stage of cataloguing empirical data, and an immense amount of work has to be performed before we can understand the factors controlling the phenomena which we observe. A new technique, not to say a new science, must arise. Nevertheless, let us not tarry any longer, but let us start unravelling all over the world the mysteries of the fauna of the soil.

Appendix. In order to get some data regarding the fauna of the soil in U.S.A., I brought with me two Berlese funnels, which were made use of at the Forest Experiment Station near Asheville, North Caro-

---

*) 2 straying ants.

lina. Fig. 10 gives the result of two such analyses of litter under a shortleaf pine tree. As in Europe the *Collembola* and the *Oribatidae* dominate and the other arthropods are not very conspicuous as to number of specimens. The number of species is, however, far greater than what I have found in Sweden and, as a matter of fact, these two samples taken at random contain so many interesting forms, some regarded as rather rare, that it seems warranted to give a preliminary list of them.

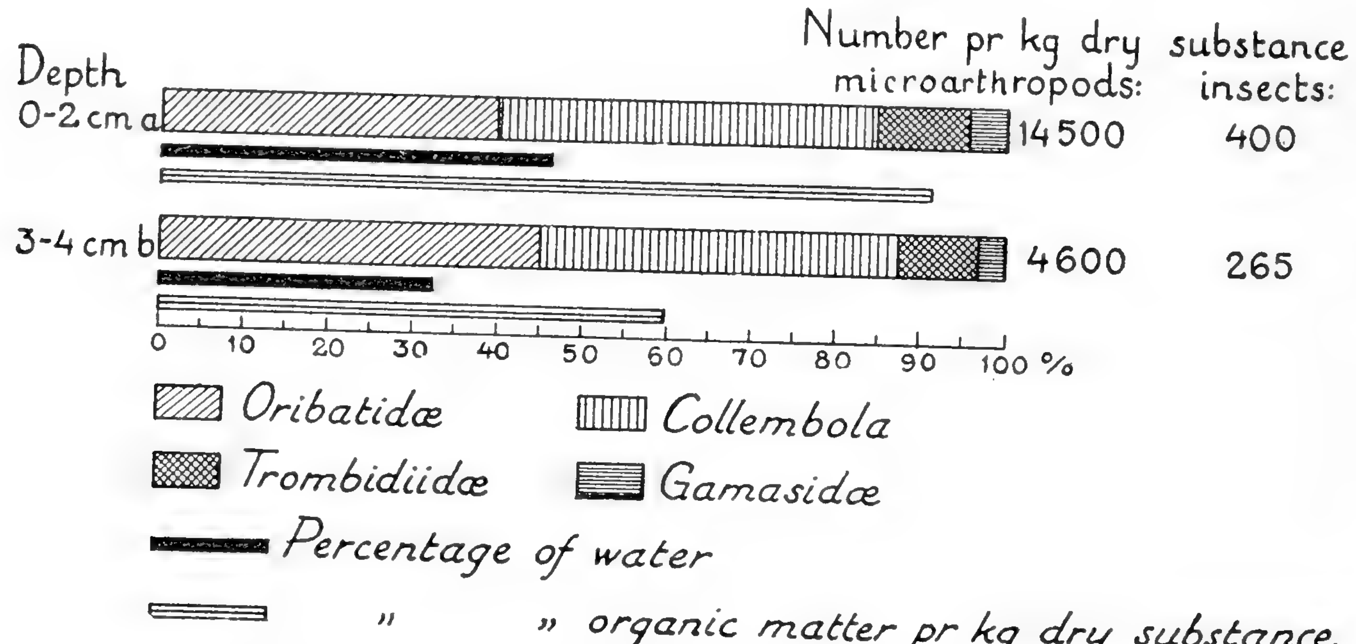


Fig. 10. — Analysis of the fauna of two layers of litter under a shortleaf pine. Asheville, North Carolina. 31. V. 1928.

Myriapoda: *Lithobius* 3 sp. *Eurypauropus* 6. *Pauropus* 1. Protura 4.

Arachnidae: *Spiders* 5. *Pseudoscorpions* 5.

Insects: *Physopoda* (2species) 15. *Claviger* 2. *Chalcididae* 3. *Wingless Mymaride* 4. *Dipterous larvae* 8. *Coleopterous larva* 1.

Acarina: *Caeculus* sp. numerous. *Labidostoma*. *Nothrus* 3 species. *Tectocepheus* sp. *Carabodes*. *Hermannia*. *Liacarus*. *Damaeosoma*. *Suctobelbea*. *Hoplophora*. *Hypochthonius*. *Zercon* (2 species) and about 20 other species not yet indentified.

Literature.

1. Berlese, A., Apparecchio par raccogliere presto ed in gran numero piccoli artropodi. Redia II, 1905, p. 85.
2. Tullgren, A., En enkel apparat för automatiskt vittjande av sallgods. Entomol. Tidskrift, 1917.
3. Russel, John, The microorganisms of the soil. London 1923.
4. Pillai, S. K., Beiträge zur Kenntnis der Fauna der Waldstreu. Kiefernstreu-Untersuchungen. Zeitschr. f. angewandte Entomologie, Bd. VIII, H. 1, 1922.
5. Pfetten, J. von, Beiträge zur Kenntnis der Fauna der Waldstreu. Fichtenstreu-Untersuchungen. Ibidem. Bd. XI, H. 1, 1925.
6. Trägårdh, I., Acariden aus dem Sarekgebirge. Naturwissenschaftliche Untersuchungen des Sarekgebirges in Schwedisch-Lappland, Bd. IV, Lief. 4.
7. — — Acariden aus Ägypten und dem Sudan. Results of the Swedish Zoological Expedition to Egypt and the White Nile 1901. N. 20, 1904.
8. — — Acari (First Series). Biospeologica No. 22. — Archives de zoologie expérimentale et générale. 5e série. T. VIII, 1912.

Berichtigungen zur Kenntnis des Baues von Insektenflügeln.

Dr. Othmar Em. Imhof, Königsfelden, Switzerland.

Es ist wohl immer eine unangenehme Entdeckung, wenn in einer neuen Zeitschrift oder in den Memoiren einer neuen Institution wie der Internationalen Entomologie-Kongresse nicht vollkommen ergründete oder gar falsche Descriptionen und Abbildungen enthalten sind und es wird wohl sehr erwünscht sein, wenn in solchen Fällen möglichst bald Berichtigungen gegeben werden.

Es sind in den Memoiren unseres zweiten Kongresses in zwei Abhandlungen Beschreibungen und Abbildungen zu präzisieren.

1. Navas: Algunos Organos de las Alas de los Insectos (p. 148—173 u. Fig. 1).

Panorpa. — Vorder- und Hinterflügel haben mehr als zwei „Pupillen". Die dritte Pupille dürfte wohl übersehen worden sein. Es findet sich dieselbe im Vorderflügel in dem Dreieckfeld des Postcubitus. Im Hinterflügel ist diese Pupille sehr schwer zu erkennen, in ähnlicher Lage neben der Flügelwurzel, in einem oblongen Feld exterior einer charakteristischen, unscheinbaren, bisher nicht beschriebenen kurzen Radicialrippe, die in gleicher Lage im Vorderflügel nicht vorhanden ist.

Diese Radicialrippe ist auch bei Myrmeleoniden im Vorderflügel zu erkennen. Für die Panorpaflügel ist noch als charakteristisch hervorzuheben, daß Ala anterior an der Basismembranula und die Ala posterior am Anfang der Vorderrandrippe starre Stachelborsten, die bisher nirgends beschrieben sind, in bestimmter Zahl, Stellung und Stärke bei den verschiedenen Species haben. Es ist auch noch nicht erwähnt, daß die Alae der Panorpiden Doppelbeborstung der Membran besitzen: feine dichte Beborstung und je nach der Spezies lokalisiert, oder in den ganzen Flügelflächen mehr oder weniger dicht lange Borstenhaare.

2. Horváth: Études Morphologiques sur la Construction de l'Elytre des Cicadides (p. 422—432, Fg. 7 et 8).

Die Familie der *Cicadidae* ist in der Litteratur in unzählbaren Zeichnungen dargestellt. 1906 gab Distant einen Katalog mit Determinationen der Subfamilien, Divisionen und Genera.

1912 und 1914 erschienen die Bearbeitungen der Genera in den Genera Insectorum, Wytsman. 85 Genera sind in den zwei Faszikeln mit je 1 Species auf 10 Tafeln abgebildet. Wer Cicadidenbeschreibungen und Abbildungen gemacht hat, weiß, wie schwer und anstrengend diese Bearbeitungen sind und wie wiederholt der Beobachter sich täuschen kann, bis er glaubt, den Bau exakt erfaßt zu haben.

Bemerkenswert für die Familie der Cicadiden ist, daß 176 Genera, also die große Mehrzahl, die gleiche Rippen- und Felderbildung der Vorder-

flügel haben. Die Hinterflügel dieser Mehrzahl sind in der Anordnung der Rippen und Felder ebenfalls gleich gebaut, aber in der Zahl der Pseudomarginalfelder ergeben sich verschiedene Typen. Die Mehrzahl hat 6 Pseudomarginalfelder, einige Genera 5 und einige 4 nach dem Determinationsschlüssel von Distant.

Eigenartig für die Vorderflügel ist, daß sie gar keine wirklichen Randrippen, Randfelder begrenzend, besitzen. Die Felder der Vorderflügel sind: Proximalteil 3 Felder. Proximal-Distalteil 2 Felder. Distalteil 2 Binnenfelder im Vorderrandteil und 9 Pseudomarginalfelder.

In den Genera Insectorum sind leider bei allen Gattungen mit diesem Flügelbau die Pseudovorderrandfelder nicht abgebildet, ebenso die eigentliche vordere Rippe des sog. Rautenfeldes. Die Abbildung des Vorderflügels in den Memoiren des Kongresses von 1912 von Horváth ist auch nicht der Wirklichkeit getreu.

1905 gab ich in der Festschrift für Professor Ehlers, Zeitschrift für wissenschaftliche Zoologie, eine exakte Darstellung der den ächten Cicadiden eigenartigen Flügelquerartikulation und eine Beschreibung der Cicadidenflügel, wie sie die große Mehrzahl der Genera aufweist. Zu meiner damaligen Beschreibung kann ich noch zur Vollständigkeit beifügen, daß am Hinterflügel der unterfaltbare Teil die einzige wirkliche Randrippe hat, indem die Außenrippe, die die Pseudomarginalfelder und die drei Proximalfelder von dem unterfaltbaren Teil begrenzt, sich auf den Hinterrand fortsetzt. Auch bei den anderen 10 Genera dürfte jedenfalls die durchsichtige Quermembranfaltungsstelle zu erkennen sein wie bei *Chlorocysta* und *Cystosoma*.

Die Cicaden gehören zu den kräftigsten und gewandtesten Fliegern der Insekten und leben in der Zeit und in den Gebieten der größten Sonnenglut. Darin liegt wohl der Grund, daß wir von den Tieren noch nicht sagen können, daß wir ihre Lebenstätigkeit vollkommen kennen.

Forum on Problems of Taxonomy: Determinations.

I. B. Corporaal, Zoological Museum, Amsterdam.

On the topic of determinations I have to offer a few remarks only. The answer to the question before us seems to me to depend largely on circumstances. A specialist in a group of wide economic importance, such as mosquitoes or weevils for instance, may often be asked to determinate large numbers of specimens, or worse still, single and often defective examples without precise indication of locality, the study of which is for himself as a rule of comparatively little interest, but frequently demanding considerable time. In such cases I think the specialist would fully be justified in asking for some remuneration for the work.

On the other hand, a specialist in a less common group, for instance in my own group, the *Cleridae*, is glad to receive material for naming, because this will enable him to enlarge his own collection, or that of his museum, from the duplicates.

I think it was the Brussels Museum which, before the war, made it a practice to appoint specialists to classify the museum material of their specialities for a remuneration of 50 francs a day, at that time a liberal sum. This seems to me a good practice. The worst possible method in my opinion would be to pay per specimen or species, because this would encourage superficial work or even actual falsifications. I am told that there are specialists who, for 2 or 3 cents per specimen, will give any name to any specimen in their group. For the benefit of conscientious specialists it should be borne in mind by those who require their services that it is highly desirable that the specialist should see all the material at hand, with full data, as only the specialist can judge of the more minute differences of nearly allied species. It is a wrong practice that, for the sake of having to give fewer complimentary specimens, the owner of a collection sends in only a few individuals out of what he considers to be a series of one species.

It will always be difficult to know as to whether a specialist is reliable in every way. I think that in this regard a central international institute as advocated by Dr. W. Horn would act as a mediator.

Discussion.

F. Muir: — In both scientific and economic work exact determinations are absolutely necessary, and some means of cooperation and coordination must be found, if progress is to be made. Already a certain amount of unofficial cooperation is in existence, and it should be our aim to extent this and, if possible, make it more official. All central museums, where types should be placed, should be provided with a staff large enough to cope with this work for *bona fide* entomologists. So far as they are able, they do this already. The Imperial Bureau of Entomology in London is a nucleus for this work within the British Empire, of which many avail themselves.

There can be no moral obligation on private workers to determine material of others, but very few good taxonomists ever refuse their help to their co-workers.

It would be a great advantage to entomology, if museums would employ specialists for stated periods to work on certain groups, paying a definite salary for such work. Experts could then move from place to place and thus extend their knowledge and so be of still greater value to the museums. A specialist, by moving round between a certain number of museums, could keep his group in those museums right up to date and make a living. Such a system of travelling specialists would be a great benefit to the museums. The payment of such work will become absolutely necessary, as the museums cannot keep enough specialists on their staff to do all that is needful and they have no right to expect private specialists to work at their material for nothing. They would not expect it of a lawyer or an engineer! The scale of recompense for such work has yet to be fixed.

What courtesies should be extended between brother specialists should be left to their own discretion, and in time an accepted custom will arise. Definitely stated sentiments on these subjects at the International Congresses will be of great help in arriving at better international understanding.

F. Silvestri: — It is true that expanding research in ecology, life histories, morphology, genetics and applied entomology has not been accompanied by a corresponding increase in taxonomists. This state of affairs has two great inconveniencies: first, the taxonomists have been over-charged with many requests and have lost too much time that they could have better employed in increasing the systematic knowledge of the group of their specialisation, and second, notwithstanding the good will of the existing systematiste, they are frequently not in a position to name the insects submitted to them, with very dangerous consequences for science, because non-taxonomists, if not careful enough, use incorrect names, or if conscious of their responsibility, publish biological, anatomical or other notes citing the genus, but referring to the species as sp. x.

All this is very lamentable, and we surely are in accord in demanding a remedy. How can we succeed in this request? By demonstrating in active propaganda the fundamental importance of taxonomy, by showing the practical difficulty in scientific working on the part of the non-taxonomist, and by publicly critisizing all the wrong or faulty determinations of the insects used in any other study than taxonomy. If the necessity of taxonomy is rightly understood, then will follow the appointment of specialists, who should be numerous in museums and well paid as scientific workers, so that they can be placed under the obligation to assist other scientists of the same nation by naming species for their studies. Such specialists, however, can only be requested to assist people of other nations as a mark of mutual courtesy.

As regards private specialists, we all wish to extend the greatest kindness possible towards these naturalists; but we will not demand that the private specialist, who frequently sacrifices much time and money for his scientific pursuits, be obliged to determine insects for other people *gratis et con amore*. He should receive at his request in exchange for his services either specimens or money or both in proportion to the value of his work.

See also *antea*, Dr. W. J. Holland's article on Museums and Specialists, p. 278.

Forum on Problems of Taxonomy: Collections.

Dr. R. Jeannel, Muséum National d'Histoire Naturelle, Paris.

Les collections sont indispensables au développement des recherches entomologiques. Leur accroissement et leur multiplicité sont tels qu'il devient de plus en plus difficile aux intéressés de les consulter. Une organisation rationelle des collections publiques deviendra bientôt nécessaire et un institut international d' Entomologie pourra sans doute contribuer à la réaliser. En tout cas il nous semble qu'elle devra se faire suivant les quelques principes suivants:

A. Centralisation des collections nationales.

S'il est désirable que chaque grande ville possède un Musée d'Histoire Naturelle destiné à l'éducation populaire, il est par contre à souhaiter qu'un seul Musée National contralise le plus possible les collections d'étude et accumule des matériaux du monde entier. Les collections des Musées secondaires de chaque pays devraient être limités à la faune locale.

B. Collaboration des Musées nationaux.

La science est internationale et il est de l'intérêt de tous que les collections de chaque Musée national soint les plus riches possibles. D'autre part une entente internationale devrait faciliter la communication des matériaux d'étude de Musée à Musée. On peut envisager les principes suivants:

1. Répartition automatique des doubles entre les divers Musées nationaux.

2. Communication des matériaux d'étude et même des types de Musée à Musée. Afin d'éviter les dangers de faire voyager les types par la poste, ces communications pourraient sans doute se faire par voie diplomatique, par une entente entre les divers gouvernements.

3. Intervention des Musées nationaux auprès des propriétaires de grandes collections typiques, afin de servir d'intermédiaire entre les propiétaires de collections et les travailleurs ayant besoin d'en consulter les types.

C. Rapports des Musées et des Spécialistes.

Les Musées ne doivent pas perdre de vue qu'ils ont besoin des spécialistes pour déterminer leurs matériaux et augmenter leurs collections d'étude. D'autre part, les spécialistes ne peuvent efficacement travailler que s'ils ont à leur disposition une riche collection particulière. Il est donc absolument légitime que les Musées rémunèrent les spécialistes travaillant pour eux, en leur faisant don de doubles dans une large mesure. En procédant ainsi les Musées ne font qu'augmenter l'instrument de travail de l'auxiliaire indispensable que le spécialiste est pour eux. Ils font même la plupart du temps,

tout à la fois, un bon placement, car leur principale source d'accroissement est constituée précisément par les collections des spécialistes qui leur font retour par voie de donation.

Discussion.

G. F. Ferris: — The idea of strongly centralized control of collections, such as that of making a single institution of the character of the United States National Museum a repository or all types should be opposed on the following grounds:

While the theoretical advantages of having a single large institution to the care of which all important material is committed are apparent, there are certain dangers in such procedure. These dangers are those which are to be found in any kind of centralized control, for any such institution would have in its hand the power to interfere with and to impede independent workers — a very real danger. The control of collections would mean the control of the work of those dependent upon such collections.

It were far better to strive for the building of several independent collections. Still better would it be to develope systematic work to such a degree that the necessity of relying entirely upon types should be reduced. Our aims should be centered upon the improvement of our methods of work. The other will take care of itself.

F. Silvestri: — The collections of insects are indispensable for any scientific or practical research in entomology, therefore are economically justifiable; but, though a specialist can be owner of a collection during his life, generally speaking the collections of insects should belong all to Government Museums or public foundations, in wich institutions they must be centralized, carefully kept and enriched by additions made through the collecting staff or by exchange. It is very important to recommend the closer cooperation between the keepers of collections in such a manner that the surplus specimens serve for building up other collections in other parts of the world. And it is necessary to keep always in mind that generous assistance must be accorded to Museums for completing the chief collection in its possession. For instance, if there were three leading collections of *Coccidae* in Museums of American, Asia, and Europe, it would be very desirable that cotypes of any described species were distributed between these institutions.

Specialists who are not employees of Museums or of public Institutions, are very worthy of praise for their work and the material that they collect, purchase or acquire by exchange. But as the owners of such collections are private men, no law must be enforced. Specialists, however, should bear in mind the value of their collections for science and, if their economic circumstances permit it, should leave the collections in the care of a Museum as soon they cannot keep it conveniently, or at their death, or, if obliged to sell the collection from economical necessity, they should be willing to conciliate their interest with that of science by making a generous and equitable arrangement with a Museum.

E, P. Van Duzee: — Dr. Jeannel recommends the formation of one central National Museum in each country. This may be entirely practical in the smaller countries of Europe. In the United States distances are

so great, it seems that the regional museum is almost a necessity. In California we feel that it is our duty to build up a large collection of insects, as complete as possible, so our western students will have material available for monographic work without incurring the expense of making the long and expensive journey of 3000 miles to study in the National Museum. In many cases the expense of such a trip would be quite prohibitive. We also feel that the types of the Western species should be deposited in the West, where they can be studied in connection with the long series of specimens of these Western species available in our Western museums, which are and always will be far superior to the series in any Eastern museum.

There is one point that I wish to emphasize supplemental to the remarks of Professor Ferris. The series of insects being built up at the California Academy of Sciences is rapidly reaching the point where it will be impossible for any one properly to treat of our Western species without studying the material in that collection and when that time comes, it will be of the greatest importance that the types of these Western species be available for study in connection with the series showing variation and geographical distribution.

In reply to a question by Mr. Morrison, I should like to say that the California Academy of Sciences is glad to send out material for study by specialists as a loan in the case of determined species or, in the case of undetermined material, with the understanding that the types and uniques shall be returned, but that the student shall have the privilege of retaining the second, fourth, sixth and eighth specimens from duplicate material. Types are not loaned out except in a few cases for monographic work of the greatest importance and then only where they can be conveyed in person, and where there is assurance that they will be properly protected from fire and damage.

F. Muir: — Collections are absolutely necessary for the advancement of entomology. Each country should have local collections according to its needs, containing well authenticated named specimens of the insects of the particular country. Besides this, there should be large central collections having world wide material available to serious students. These collections should be financed by public money. Private collections are the property of the owners, and no one has any moral right to them, and all action on the part of the state to control them in any way should be discountenanced by all entomologists. An entomologist has as much right to the results of his labour as any other man. Such of these private collections as are of great scientific value should be acquired eventually by the big central museums whenever possible; but this should be done in the open market, and no form of state compulsion should be used.

The leading central museums should arrange an exchange of all available material. Most large museums have quantities of duplicates which would be of great value if they were distributed. The time necessary to sort out and label duplicate material is one of the factors holding such work back. Central museums should make provision for this task.

Types should be loaned to Institutions of good standing in limited quantities and for limited periods. The question of loaning to individuals should be judged upon the merits of the individual case. Most workers can

get in touch with some Institute of good standing through which they could borrow, and where they could examine the material. Entomology is served better by types being examined by specialists, with a chance of loss, than by being kept in iron safes. Types are like money, both being of little value if not used for circulation.

Specialists who determine or describe material belonging to museums should be entitled to a percentage of the material, the type specimen of a new species being returned to the museum. When doing this work for small local museums where type material is likely to be neglected, or destroyed through climatic conditions or want of adequate supervision, then it should be arranged that the types be sent to some central museum.

Remarks on the Insect Collections in the Museum of the California Academy of Sciences.

E. P. Van Duzee, San Francisco, Cala.

The early collection of insects in the museum of the California Academy of Sciences was destroyed by the fire following the earthquake of 1906. The only exception to this was that certain of the types had been segregated, and these were saved by the faithful and determined efforts of members of the Academy staff. The types saved were the Horn types of the Coleoptera, the Uhler types of the Hemiptera, the Fox types of the Hymenoptera and the Pergande types of the ants. At the time I arrived in Californis in 1912 there was no available general collection of insects where I could obtain the names of even the more common Californian insects. Dr. E. C. Van Dyke and Dr. F. E. Blaisdell had large collections of well studied Coleoptera and were always ready to determine any beetles I might find, but aside from my own collection of Hemiptera there were no determined collections in other insect orders.

The present collection of insects at the California Academy of Sciences numbers by actual count about 750,000 mounted specimens. This collection has been built up largely by the generosity and cooperation of California entomologists who have presented to the Academy their private collections. Most of these collections have been presented under an arrangement that allows the owner to retain control of the collection during his life time with the privilege of withdrawing for home use any material from his collection he may wish to study. Among the more important collections acquired by the Academy are the W. G. Wright, the F. X. Williams and the E. J. Newcomer collections of Lepidoptera, the E. C. Van Dyke, F. E. Blaisdell, L. S. Slevin and J. O. Martin collections of Coleoptera, my own collection of Hemiptera and the large Albert Koebele general collection of insects. In addition we have the material taken by the curator and his assistants on various expeditions and in field work about California.

The Academy has adopted the system of unit boxes, used by the United States National Museum, for all smaller insects including the Coleoptera, Hemiptera, Hymenoptera, Diptera and the Microlepidoptera. The Macrolepidoptera, Orthoptera and most of the Neuropteroid orders are arranged in drawers, the butterflies in glass-bottomed drawers to show the lower surface of the specimens.

The matter of the determination of the material is a serious problem with us as it is with all museums. The Coleoptera are well cared for by Dr. Van Dyke and Dr. Blaisdell with help from Mr. Martin in certain groups. I can myself attend to much of the Hemiptera; Dr. Wm.

Barnes has very generously determined many of our Lepidoptera for us. Dr. F. R. Cole has worked up most of the Diptera with help in certain families by my brother M. C. Van Duzee and others. Prof. Cockerell has worked up many of our bees and we have had help in other orders by various students.

The Academy collection of types, numbering over 2500 holotypes and allotypes, has been segregated in a portable metal case. These are entered on a register, numerically, as received. Paratypes are kept in the general collection with a special paratype label so they can readily be detected. The Academy prints all its own labels and all data are kept with the specimen. These data consist of the locality, as exact as possible, the date of capture, the name of the collector and where known, the food plant or similar ecological data.

The aim of the Academy is to build up a general collection of insects in series sufficient to show variation and distribution, to enable Western students to work up their fauna as it should be done, and to assist in monographic work.

The Locust Question in Soviet Russia.

I. N. Filipjev, Bureau of Applied Entomology of the State Institute of Experimental Agronomy, Leningrad, U.S.S.R.

(With 1 map.)

The Locust-plague has been known in Russia for nearly a thousand years. It is known from the old Russian annals that the regions of Kiev, Kursk, were sometimes subject to very intensive locust invasions that ruined nearly the whole crop of those regions. Great invasions are known to have occurred in the XVI. and XVII. centuries in the regions of the Ukraine, from Polish historical sources. Dense clouds of locusts were then flying from the Ukraine, where they probably originated, through Poland to Middle Germany and Latvia. Considerably more locust years are reported in the XIX. century, which is in connection with the expansion of the Russian Empire to the South, where breeding places of many species of locusts are more numerous. The last period of locust increase on vast territories is quite recent: the years 1921—25. But there is no year when locusts are quite absent from the territory of our Union.

There are four species of locusts concerned in damaging crops in our area: 1. the Asiatic or Migratory Locust *(Locusta migratoria* L.), the best known one of the larger species of grasshoppers of the Palaearctic region, 2. the Moroccan Grasshopper *(Dociostaurus maroccanus* Thunb.) and 3. the Prussian or Italian Locust *(Calliptamus italicus* L.), both of middle size, and 4. the Siberian Grasshopper *(Gomphocerus sibiricus* Thunb.), one of the small-sized species. Each of these have their own region of propagation. In most cases in the regions of the Asiatic and Maroccan Locusts the damage is done by these two species alone.

The Asiatic Locust *(Locusta migratoria* L.) is one of the best known species of harmful insects in Russia. The principal features of its biology are known in literature as early as in the XVIII. century from German authors. A very good Monograph with many historical data was given by Koeppen (1870), but the principal features of the ecology were cleared up only by Lindemann and other authors (about 1883), which led to the fundamental conclusion that this locust is a swamp insect. This view is prevalent in literature till now. Only the investigations and observations of quite recent times could somewhat alter this opinion as being right for the South only. Another Monograph with many interesting data on the behaviour of this species was published by Nikolskij (1915).

As is well known, this species occurs in nearly all the territory that it could reach by flying and which is suitable for its habitation, i. e. all the tropical and southern temperate region of the Old-World; but the increase in masses that renders it harmful does not occur everywhere.

In our country there are two quite different places of such an increase: — in the South there are the regions around the large swamps of the great rivers and of the lakes in the region of the Black, Caspian and Aral seas, and further to the East in Central Asia. These swamps are surrounded by the desert zone or by steppes. The latter extend further to the North, but in that zone such increases never occur. But still further North we find again places of increase, in the Southern border of the forest zone, occupying the whole of Northern Russia. Further in the North again there are no constant breeding-places of this Locust. They arrive, lay eggs sometimes, but do not breed, or after propagating for some years are exterminated in a colder year. The dampness and the insufficiency of warmth are the limiting factors to the North. It seems that the isotherme of 13.6° C limits pretty well the birth-places of the Locust in the Eastern part of Central Russia (Predtetshenskij).

According to Uvarov *L. danica* and *L. migratoria* are forms of the same species, the first being the solitary, the second the swarm phase of the species. This view is shared by nearly all investigators and is corroborated by field observations, as well as by the experimental data of Plotnikov, from which it is seen that singly bred locusts receive the caracters of *danica* and that specimens bred in dense masses become *migratoria*. This opinion is in opposition to the view of Plotnikov who tries to prove the existence of two hereditary races which cross at some time. For the time being both opinions are to be regarded as not yet proved and as needing further evidence, particularly experimental evidence. But very many indications oblige me to adhere to the opinion of Uvarov, particularly in its last (1927) modification, where the purely external causes, i. e. the mode of breeding, is regarded as cause for the appearance of the one or the other form. Very interesting indirect evidence for the correctness of this view is presented by Predtetshenskij in his studies of the Middle Russian Locust. This species is a constant inhabitant of these countries and is represented there by a small form generally determined as *danica*, although different from the Southern *danica*. The increase during late years was not caused by swarms from the South, as was generally supposed till now, but by the increase of local locusts owing to favorable meteorological conditions. The swarm phase locusts that were the product of this increase showed themselves as differing in the same way from the single-living phase as do those of the Southern race, which supports the conclusions of Uvarov. The name *danica* must be confined to the Northern race, the "phases" receiving new rational names proposed by Plotnikov and Predtetshenskij: *solitaria* for the form living singly, yet in many generations, *accumulata* for the swarm form, and *dispersa* for the dispersed descendants of swarm-individuals, somewhat intermediate in character between the first two. The existence of such phases (or possibly better "morpha") is known of several other species of swarm-forming locusts.

The breeding-places of this Locust in the South are confined to the swamps, where the Locust finds good places for oviposition on the borders and an inexhaustible source of food in the chief plant of these swamps, the reed *(Phragmites communis)*. This Locust is confined in its food to gramineous plants. The experiences of the last years lead us to

the conclusion that there is no instinctive preference in any stage of development for such biotops. This preference is based only on food-supply both in the larval and in the adult stage. The larvae begin to feed where they are hatching. The adults, after flying, stop where they find food, that they need for the ripening of their eggs. Only in the desert and steppe zones, to which the above mentioned swamps are confined, do they find the green food they need, under natural conditions the surrounding steppes being burned up by the sun of the dry Southern summer. Some swarms find their food on the corn or millet fields in the green gramineous plants in the late season, the egg-laying occurring very often in such places. Some swarms fly into the mountains, where they also find green food and oviposite although that is equal to suicide, as they do not hatch there. In some years, when the summer rainfall is sufficient, the steppe remains green in the autumn instead of being burned up as usual. Large swarms can then find here their food and considerable oviposition may occur here. If the rainfall in the spring and early summer is sufficient again, the Locusts can grow in the steppe to full maturity. As this occurs very often in desert regions with a very scarce population, such places remain often unrecorded by the Plant Protection Service and give some unexpected inconveniences, as for example the outbreak of the year 1926 in Ciscaucasia. Formerly these deviations from ordinary swamp places for egg-laying were considered as deviations from normal breeding instincts. But the above observation gives a more simple explanation of the matter. Another factor influencing the selection of oviposition-places is the marked thermotropism of this species. It works the more powerfully, because egg-laying occurs very often in late autumn, when the temperature becomes low and the locusts fly very likely to places more warmed by the sun. Sometimes this thermotropism dominates over the food-chemitropism, well warmed places often being without any vegetation. Sometimes oviposition takes place there, if the condition of the ground does not prohibit it. This conception explains the cases of oviposition observed in salt grounds, where, on account of the dampness in the spring, all the posterity perishes drowned in the mud.

The hatching places in the North studied by Predtetshenskij are not of the same nature as those in the South. The warmth being deficient and dampness excessive, the hotter and drier biotops only can be inhabited by the Locusts. Such are the sandy places. But these are overgrown in all northern hatching places by the fir-forests, shading the ground and therefore rendering it unsuitable for the Locusts. Man's work is here welcome to his enemies: the clearings and fields, particularly the fallow fields, are the suitable biotops. From these the Locusts pass to the winter and summer fields, where in some years they do much harm to forest-borders, landmarks, meadows, but avoid definitely the swamps and their "favorite", the reed.

The positive thermotropism, as proved by Nikolskij, is the chief moving cause of the behaviour of the larval stages also. In their daily migrations the larvae always try to find the warmer places. They pass the night on the plants, and when the soil becomes warmer than the air, they descend and form little herds, that, owing to their dark

color, absorb the heat of the sun-rays. In the evening, owing to the radiation, the soil loses its heat sooner and the larvae crawl on to the plants in the air that remains warmer; possibly, the last oblique rays of the sun are also utilised. Only in the hottest time of the day when the soil is heated up to 50° C and more, the Locusts avoid the direct rays of the sun and try to hide themselves in the shade of plants, stones, lumps of soil, etc.

There are many different opinions about the causes of the migrations both of the larvae by walking and the imagines by flying. Both are a result of an inborn instinct, or better a reflex, which is chiefly released by heat; this generally occurs in the hottest part of the day when even the hungry larvae cease to eat and begin their remarkable migrations. It is possible that in some cases hunger can be a contributory cause; for the herds in hungry places are more continuously on the move. The very interesting observations of L. Z. Zacharov contain some evidence that the direction taken by the herds of larvae is quite indefinite, being determined by some accidental cause at the beginning of the march. An isolated herd was observed to take a very indefinite winding course when external conditions did not force it to take a more definite direction. We often observe a march in one direction on one side, and in another direction on the other side of a narrow river or a channel. Larger herds, if some direction is once taken, are obliged to keep to it by the closeness of the crowd. Such large herds keep their direction very constantly, often leaving the reeds for the steppes or the neighbouring desert, where they may perish because of absence of food. They swim rivers, even large ones, such as Syr-Darja in Turkestan. It is a very difficult matter to deviate them from their direction, as is attempted by some of the controlling personel, and to-day the very definite advice is to adapt oneself to such migrations.

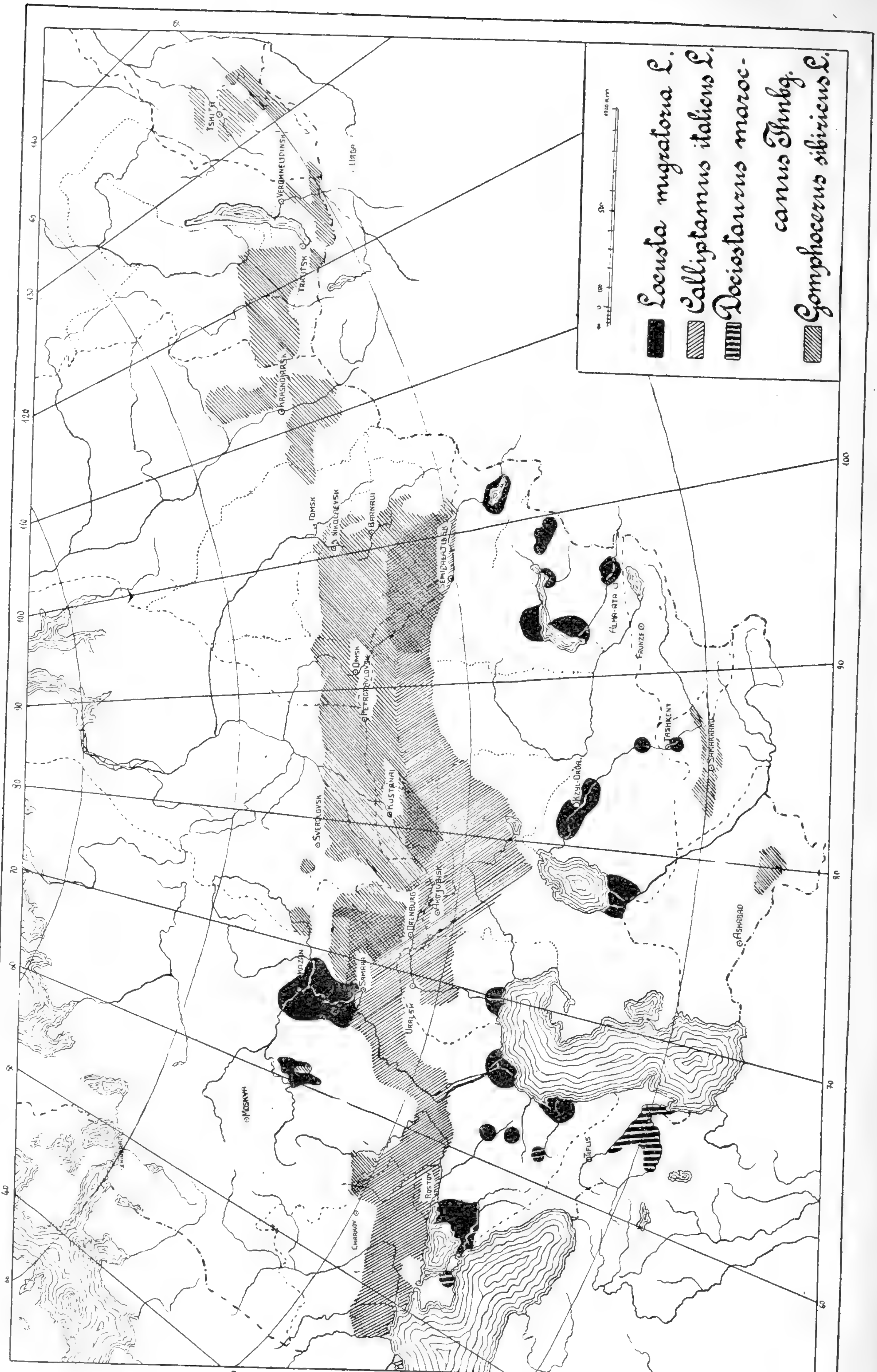
The flight of the swarms is one of the features that calls most attention to this species. The flight is not very fast; the velocity of the swarms is observed to be nearly 15 km (8—9 miles) per hour; and the flight is not very high, about up to 30 m (100 feet). From a distance a large swarm is like a low-sailing cloud. The flight begins with small swarms flying around near the places where the Locusts developed wings; then the little swarms unite and form a larger one, which then starts on its journey, travelling 300—500 km (200—300 miles) and even more. As in the case of the march of the larvae, so also the flight is caused by an inborn reflex, released by some external and possibly internal conditions. The possibility of the latter suggestion is shown by V. P. Pospelov, who regards the flight as an adaption for the heightening of the internal body-temperature needed for the ripening of the ova, this process being bound up with the symbionts of the fat-body. The direction of the swarms is determined chiefly by the winds. That was very clearly seen at the time of the large Ciscaucasian flight of 1926. The flying began at the period of the domination of the eastern winds, and the swarms were flying far into the cultivated part of that land. When the winds turned to the west the Locusts returned to their steppe birthplaces of that year. Very often the flight begins across or even against the wind, but the swarm was always seen to turn after a little time in the

direction of the wind. The directions of the flights have decidedly nothing inborn in them. Their definiteness is easily explained by the constancy of meteorological conditions at that time of the year; the supposed definite ways, if they really exist, are explained by the air currents that exist at day over the rivers with swamps along them, or by the currents in the valleys, or by the hunt for food that, in desert places, can only be present along the line of the swamps of a river. This vagabond instinct is the reason why the herds of this species seldom occur in quite the same places as in the foregoing year. Generally, when one comes to the birthplace after the flight has begun, one finds there nothing else but the eaten reed, a mass of manure and some few remaining specimens. As a rule oviposition occurs in a quite different place, often very distant. Of course, it can sometimes happen that another, or even the same swarm, comes accidentally to the starting place, but it is rather an exception than a rule, especially if there are many places suitable for feeding and egg-laying in the same district.

The periodicity of the increase of this Locust is a very marked one. The increase in the Northern parts of its area, as pointed out by P r e d - t e t s h e n s k i j and others occurs after hot summers and dry and cold autumns, coinciding with B r ü c k n e r's warmer periods. If the following years have only the average or a below-average temperature and are damper, the Locust becomes again a collection-insect only.

Some periodicities are very marked in the South-western birthplaces in the deltas of the Black- and Azov-Sea rivers. They are probably chiefly due to dampness conditions, as the temperature there is high enough each year. A similar pulsation is present in the Semiretshje and Zaisan birthplaces in the East, where possibly the cold winters are the cause of the disappearance of the Locusts. The other South-eastern birthplaces, of the Caspian and Central-Asiatic lakes and rivers, have heat and dryness enough every year. But the dryness is here more a limiting than a favouring factor, as in the damper years the areas of habitation embrace the surrounding steppes. A periodicity occurs here also, but not in the same years as in the North and South-west. In smaller birthplaces, as for example at the Kuma river in Ciscaucasia, the Locusts diminish even without any control-measures after some years and disappear as in the North; possibly this stands in relation with the flying away of the swarms from small birthplaces beyond their boundaries. But in the larger birthplaces, for example at Terek in Ciscaucasia, or Syr-Darja in Middle-Asia, there is nearly no year when an increase in masses does not occur. The causes of these periodicities in the South-east remain as yet quite unknown.

A natural control by parasites — as is shown by the available data, and by the last special studies made by the Institute of Experimental Agronomy — is of little influence on the general balance of the species. The Bombyliid flies *(Anastoechus)*, the red mites *(Eutrombidium)* and the egg-parasites *(Scelio)* are the chief parasites of the egg-clusters, but never has it been found that they lead to extinction (or nearly), although a destruction up to 60% of egg-clusters, chiefly by *Anastoechus*, is known. Its importance diminishes in the drier egg-laying places where only a small portion of the whole is infested. The larvae and adults are attacked by the same mites, which have hardly any influence on their health, and by the internal larvae of the Tachinid *Blaesoxypha* (three species) and



Diagrammatic map of the distribution of the damage done by the chief species of Locusts in U.S.S.R. The Migratory Locust occurs in two areas: a southern one where propagation is more or less constant, and a northern one where it is quite sporadic. Isolated individuals are found everywhere between the black spots. The area marked as that of *Gomphocerus sibiricus* is damaged not only by this species, but also by several other species of grasshoppers.

of a new Anthomyid. In the younger stages of the Locust larvae are killed by *Blaesoxypha,* and the adults by the Anthomyid on account of the very large number of larvae of this fly (up to 100) in the body. But the *Blaesoxypha* are ordinarily not deadly for the adult Locust, as after their exit the wound on the neck cicatrizes and the Locust can remain alive and even may oviposite.

Apparently of more importance are the fungus diseases that appear on the egg-clusters in damp and cold autumns, as well as the fungus and bacterial diseases appearing in cold and damp summers on larvae and adults.

Some assistance in the destruction afford the birds, especially the rose starling *(Pastor roseus),* which, for this reason, is especially esteemed by both the Russian and Native populations.

Special assistance is afforded here and there by inundations. The eggs remain alive when overflowed by the early spring waters, but they perish when covered by water at a more advanced season. This may explain why the increases of Locusts in the lower Volga districts are ordinarily not very serious.

The Moroccan Grasshopper *(Dociostaurus maroccanus* Thunb.) is much less known than the foregoing species. Some data of general significance are known from the older accounts of Sijazov and Sevastjanov in Turkestan, a more detailed account on biology in Transcaucasia is given by Sviridenko. This is a pest of the Southernmost parts of our country: the Crimea, Ciscaucasia, Transcaucasia and Turkestan. It is the chief locust-pest in the last two countries. During late years it has been at a minimum in Turkestan, but did much harm in Transcaucasia (Azerbajdzhan). The species is known outside U. S. S. R. along all the coasts of the Mediterannean Sea, in Anatolia, Syria, Persia. All the countries inhabited by it have a dry and hot climate. Uvarov, after a critical review of the literature and some personal observations, comes to the conclusion that the hot and dry plains of the semidesert or steppe where the principal increase occurs are only secondary birthplaces of this species, low stony mountains being their reservations. This is the case in Turkestan and the Crimea; the Transcaucasian plains receive their grasshoppers from Persia, but it is not clear from which mountains Ciscaucasia could receive them.

The larvae are gregarious like the preceding species, but their movements are not so characteristic and more influenced by insuffiency of food. The adults do not fly in such clouds as the preceding species, but infestations of an area from 100 to 150 km (60—90 miles) are known. A periodicity occurs as in the other species, but its causes are not quite clear.

The Italian Locust or Pruss *(Calliptamus italicus* L.) was formerly known chiefly from the papers of Lindemann; in recent times two studies by Dovnar-Zapolskij in the Don province and by Kiritshenko near Odessa have been published. It is much more widely distributed, occurring as a noxious species from Kiev, Tshernigov, Voronezh, Samara to the Black Sea, N. Caucasus, Uralsk and Siberia to the East. The principal dwelling place is the drier gramineous steppe zone, not the semidesert. Although it occurs in some places in Transcaucasia and during the last years was the most harmful species in some parts of Turkestan, chiefly Turkmenia (formerly Transcaspian pro-

vince). Very interesting are the dwelling places of this species at the Northern border of its area. The reservations, and sometimes the places of infection for large parts of land, are confined to hotter and drier biotops — the sands or the chalk-slopes of the land in Middle Russia. It seems more persistent, in the last years, in the Ural river region and in Turkestan.

This species, contrary to the Migratory Locust, avoids the gramineous crops, eating chiefly non-gramineous food: it attacks the sunflower, the buck-wheat, cotton; of the useless plants *Artemisia* is a much favoured one. Of gramineous crops there are eaten only the young soft green parts. Sometimes it passes the fields of wheat without damaging any plant, cleanly eating away all the non-gramineous weeds.

In the North a cold and rainy time in the larval or imaginal period seems to be the chief controlling factor, because of the fungus epizoics that occur at such a time.

The Locusts of Siberia are known from the older papers of Portshinskij, Skalozubov, and others, but very little scientific work beyond the faunistic was done. There are several species that do harm on the great area from the Volga through the Ural mountain region all over Siberia to the plains of Transbaicalia. The two species that seem to be more destructive are the Siberian Grasshopper (*Gomphocerus sibiricus* Thunb.) and the Dark-Winged Grasshopper (*Chorthippus scalaris* L.), both occupy, as Vinokurov hat ascertained for Eastern Siberia, the same biotops of steppe character, but the time of appearance is somewhat different. *Arcyptera microptera* F. W., the Cross Grasshopper, and some others are nearly always present in the swarms in some numbers; *Chorthippus albomarginatus* D. G. occupies damper biotops of meadow character; *Podisma pedestris* L. both kinds of biotops. According to the observations of Bej-Biento and some older authors in Western Siberia, it seems that the fallow fields are the chief places of increase of these species, the natural biotops being not so suitable for them. A very interesting tree-grasshopper, *Prumna primnoa* F. W., is doing harm in the Far-East (Engelhardt).

As in the preceding species, the chief natural controlling factor is the cold, rainy and sometimes even frosty, weather, especially in spring, when such weather occurs very often in Siberia. After some years of good springs the increase can become dangerous, and much harm can be done, as was the case for example in the dry and hot year of 1921. Generally in periods of 5 to 6 years the grasshoppers are numerous, giving then a respite of about the same length of time. They seem to be more constant in more Southern and hilly parts of the Ural region and W. Siberia; but Vinokurov doubts that this applies also to E. Siberia.

Much faunistic work on Acridioidea has been done during the last years. We draw attention to the papers by Dovnar-Zapolskij for the N. Caucasus, Predtetshenskij for the Astrachan region, Bej-Bienko for different parts of W. Siberia, Moritz for Turcmenia, Vinokurov for E. Siberia, and very numerous faunistic papers by Tarbinskij for different parts of European and Asiatic parts of the Union. Some of these works have a very decided ecological direction. The work is much facilitated, because of the very good systematic com-

pendiums of Uvarov, one for the European part of U. S. S. R. and W. Siberia, and the other for Middle Asia.

The general influence of the cultivation by man is that it destroys the hatching places of the grasshoppers. The fields that cover most parts of the steppe region of Eastern Europe are not suitable for the increase of the Locusts; the increases are bound up with the presence of hard soils, and therefore the chief places of the Locust plague are the eastern parts of the European Russia and the whole Asiatic part, except the forests. It was said that the most preferable places in Siberia are the fallow fields; the same could be said for some parts of Ucraine and Central Russia where the beginning of an increase of the Italian Locust is often associated with such fields and places unsuitable for cultivation. This applies also to the hatching places of the Asiatic Locust in the Northern region, where the increase in masses is made possible only by man cutting down the forests and transforming them into fields and waste-places. It is generally said that the decrease of tilled soil owing to the Civil war was one of the causes of the recent increase of grasshoppers (the same is reported to be true to-day in China).

The causes of the disappearance of the Asiatic Locust from the swamps of the Danube, Dniepr, Don are not very easy to analyze. It is highly possible that it is also bound up with the progress of cultivation. It was exactly after the great increase in cultivated land in the 90s of the last century that large increase in Locusts ceased here completely. Two possibilities of direct influence could be advanced: 1. the pasturing of the cattle in the reed-swamps, and 2. the gradual decrease of the swamps by draining; and an indirect cause: the extinction of reserve breeding-places in the surrounding steppes.

It may be assumed that the progress of cultivation does not at once exterminate these injurious insects; on the contrary, the cutting of woods and the fallow fields enlarge the suitable birthplaces. Only the further progress of cultivation, the draining of swamps, the ploughing of land is the cause of the complete disappearance of the Locust-plague.

The direct control of the Locusts, as Uvarov has said, is in our hands. Its success only depends upon the organization of the work. The proper time for control measures is the larval period only. All the attempts to fight flying swarms on a very extensive scale in 1926 in N. Caucasus proved to be in vain. The old mechanical methods, very unsuccessful and expensive, are now nearly abandoned and almost only chemical means are adopted. The mechanical methods are recommended only for exceptional cases of favorable land configuration or for deserts where the distribution of poisons is too expensive. The principal chemical method is that of poisoned baits, the cheapest and the simplest of all. It can be applied for the Italian, Maroccan and nearly all Siberian Locusts, as well as for Northern and Southern steppe birthplaces of the Asiatic Locust. Its application in the swamp birthplaces of this species is not yet possible. The tests made (cf. Moritz-Romanova, Charin, Filipjev 1926) showed that 1. the herds of larvae are moving too quickly and a portion of them always passes the bait without taking it, 2. the bait is taken essentially in a damp state, but in the hot sun becomes quickly quite dry and is not taken anymore, 3. the greater portion of the larvae climb

all the day onto the plants and eat only on the top of them. Further experience must solve these difficulties. Therefore for the Asiatic Locust spraying with hand or horse spreaders is still the chief method.

During recent years the new method of dusting from airplanes has come in. The first successful experiments were made in 1925 in N. Caucasus (Sviridenko 1926). The following years the Avio-expeditions worked in Daghestan and on Syr-Darja. This method recommends itself on account of the possibilities 1. of very quick work, and 2. of work in such places (swamps) which are inaccessible both on foot and in a boat. But its expensiveness will reserve it probably only for places of the latter character.

The organisation of locust-work is centralized. The Locust-control is decreted to be the work of the State, not of the population. Each of the seven independant Commisariates of Agriculture has its own organisation and own financial sources. In the R.S.F.S.R. all the work is financed from the centre, and the work is done by the local Stations for Plant Protection. Moving detachments under the direction of trained technical assistants and composed of specially engaged workers with some machines are formed and work during the time of the Locust control work in the first half of the summer. They are dismissed after the work is done, and the supervising staff only remains. The poisoned bait-method permits a large number of the population to participate in the work, as only an elementary instruction by the trained staff is required. The organisation of the airplane service is in the hands of the State cooperating with the "Society of the Friends of the Air-Fleet and of Chemistry" (Aviochim). Such an organization is quite enough for the protection of the crops against the Locusts and no such ravages as formerly are now observed in U.S.S.R. Further progress in cultivation and in scientific research will quite abolish the ravages of the Locusts.

For a list of Literature see Uvarov 1928: Locusts and Grasshoppers.

Life-Zones in Russia and their Injurious Insects.

I. N. Filipjev, Bureau of Applied Entomology, State Inst. Exp. Agronomy, Leningrad, U.S.S.R.

(With 3 maps.)

The distribution of animals — I have specially in view that of insects — depends on the surrounding external conditions. In an analysis we find four fundamental groups of factors. The most important are the climatic factors, then come the factors of soil and vegetation and, lastly, other animals. Man, by his farming activity, barely changes the climatic factors, but influences powerfully all the others, changing them partly consciously, partly unconsciously.

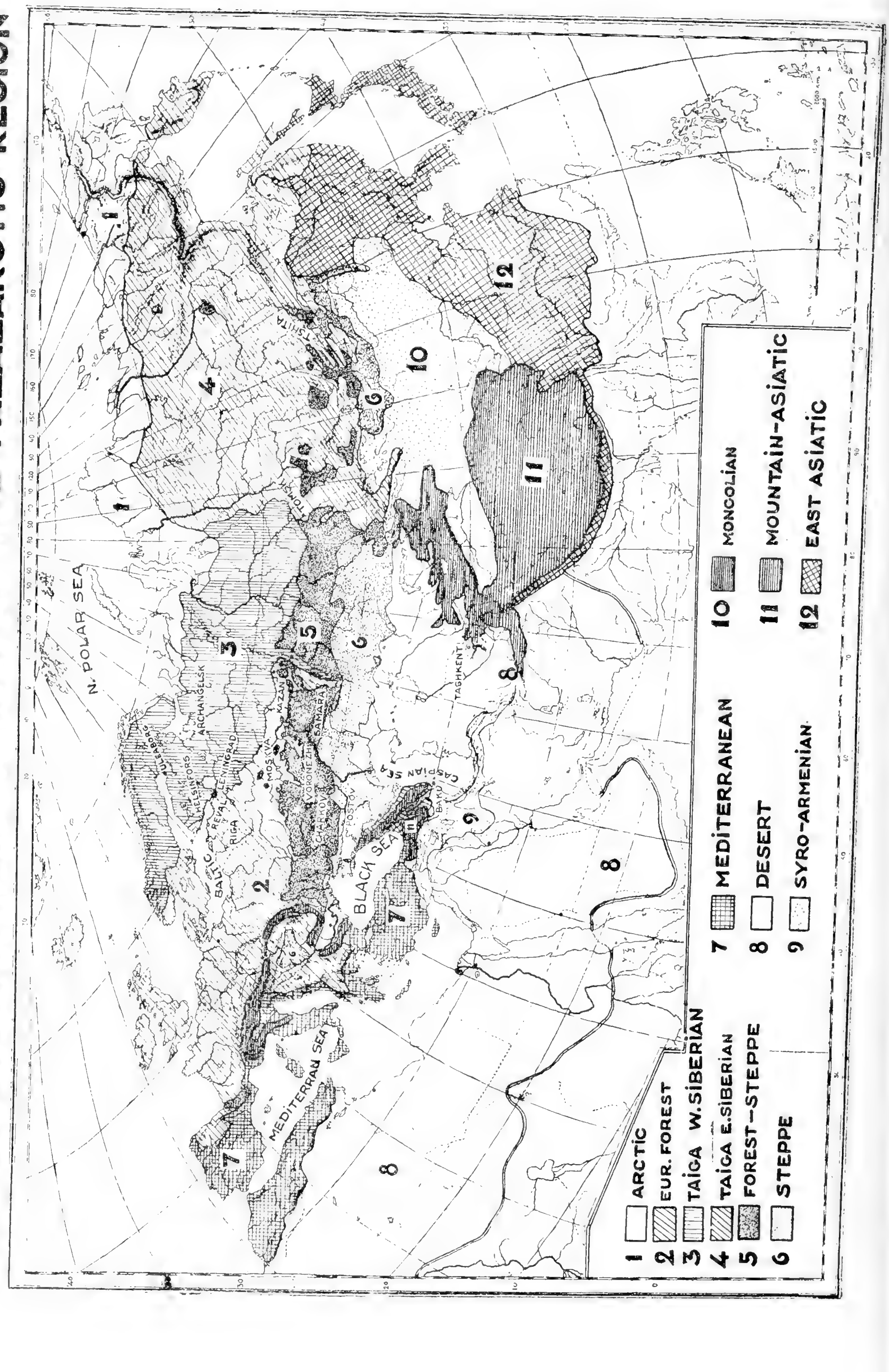
If we travel through any country, different landscapes unfold themselves before us, in which we are soon able to observe some definite lawfulness. The greatest medley is caused by the activity of man. For instance, in the forest land of the Northern part of Russia, we have hardly any natural open places. Those meadows and bushes which we see are due to the hand of man. The conditions of life in each locality are different from the neighbouring ones and accordingly the fauna is also different. We must discern and classify every such locality in studying a given district. For them we have Dahl's convenient term of biotop, and in the Russian literature the term station is widely used.

In each given place on different soils we observe a regular recurrence of different stations: a field on sandy soil sown with the same seeds will be different from that on clayey soil, etc. We can ascertain in a given district such localities with similar soil and indicate them on a map, whereas it is impossible to do so with quickly changing biotops. It is convenient to call such districts — ecological districts. In uncultured places, as for instance in the steppes of our South-east, there will be a characteristic vegetation for each district, i. e. the biotop will correspond to the ecological district, but in cultured places the position is, as already mentioned, more complicated.

Thus, every locality may be compared with a mosaic rather than with a picture with gradually changing colors. Separate elements of the fauna are connected with different parts of this mosaic picture, recurring regularly. On nearer examination this hap-hazard medley for which the population of any district of the territory might be taken appears to be much more orderly than it seems at first glance.

The recurrence of ecological districts in a definite regular sequence causes an alternation of life-zones. Each of them may be characterised by a predominance or admixture of definite ecological districts. Almost always

THE ZOOGEOGRAPHICAL ZONES OF THE PALAEARCTIC REGION



some zone or other enters into the neighboring one as islands or stretched-out fingers, sometimes forming a bordering mixed zone, or even reaching its extreme limits, being one of its ecological districts.

The existence of zoogeographic regions is dependent on historical causes, on zones, on climatic and ecological factors, on soil, and on the biotops that owe their existence to the activity of man.

The whole of Soviet Russia lies within the Palaearctic region, all its subregions being present in its boundaries. Of such we can distinguish five: The Arctic, Boreal, Mediterranean, Central Asiatic and East Asiatic.

All know the original animal kingdom of the Arctic subregion, which we are inclined to consider as one zone. Its fauna in various parts is somewhat different. However, one should note the great homogeneousness of the fauna in the Eastern half of this zone. Very many species described from E. Siberia, or even from America, exist also within the boundaries of Europe in its North-eastern marshy plains (tundra). These elements do not penetrate into the Kola Peninsula and into the polar zone of Scandinavia.

The Boreal subregion includes in the North the Forest zone, in the South the Steppe, and between them lies a mixed forest-steppe strip. Gradually passing from West to East we find the European Forest-zone, the zone of the W. Siberian Taiga and that of E. Siberia.

The East-Siberian Taiga extends to the East from the watershed of Enisei-Ob, including Tomsk and the Altai mountains. This boundary stops a very large number of insects and also vertebrates, which do not spread further to the West. On a whole this is a hilly or even mountainous region, overgrown by coniferous forests consisting of larches, pines, firs and cedars *(Pinus cembra).* The fauna is not yet well known throughout.

The West Siberian Taiga occupies N.-W. Siberia and the North of European Russia, the largest part of Finland and N. Scandinavia. On the whole this is a forest of the plains, with a large number of swamps. Firs predominate, in the East they are mixed with larches, silver firs and cedars. The representatives of the Arctic zone penetrate into its bogs. Some species are characteristic as occurring from N. Sweden to the Northern tributaries of the Amur, but not being represented anywhere else in Europe.

The Zone of European forests, wide in the West, becomes narrower in the East and wedges into the Ural. This zone is characterised by broad-leaved forest-trees: the oak, linden and others. Its Northern part gradually changes to Taiga as the same firtrees with their fauna predominate, but is very poor in Siberian elements, though these penetrate in places pretty far to the West.

In the South fir tree forests are absent, oak forests predominate. This zone is distinct owing to zoological rather than botanical attributes. The penetration of typical Siberian species from the N. E., and of European ones from the S.W. is about up to a line beginning near Leningrad and going along the middle course of the Volga and finishing in S.Ural.

The injurious insects of this forest zone (I enumerate only geographically characteristic ones) are sufficiently varied. So, the West Siberian zone includes wholly as injurious insect the "grass cut-worm" *Charaeas graminis,* which harms the hay fields, "northern stem-cutworm" *Hadena secalis,* which harms the crops by eating the inside of the stems, and *Phaedon cochlae-*

ZOOGEOGRAPHICAL ZONES OF EUROPEAN RUSSIA

ariae, which harms cabbage. It is interesting that the harming increase of the winter cutworm *Feltia segetum* for the last years in the North was almost exclusively confined to this zone (cf. map on p. 819).

In the zone of European forests damage is done chiefly by *Plusia gamma*, in the epoch of its increase in masses, as for instance in 1922, the small "Swedish fly" *Oscinella frit* (always diminishing the harvest); for vegetable gardens and for flax in some years is typical the larva of the crane fly *Tipula oleracea;* also *Pionea forficalis*, which damages cablage, is usual also in the South, but does not do there any harm. In gardens the "Sorbus moth" *Argyresthia conjugella* is typical, especially in the Northern part of this zone.

In the E. Siberian zone, in vegetable gardens in spring, we find cutworms of different species: *Euxoa tritici, E. islandica,* etc., which do no harm further to the West, at least not in spring. In forests *Dendrolimus sibiricus* ravages, but is harmless beyond the limits of this zone, although it occurs as far as the Ural mountains. One may be sure that further study of the fauna will give us some other characteristic species.

To the South of the forest zone comes the Forest-Steppe zone (savannah), differently developed in Europe and in Siberia. In Europe, the chief tree participating in forming the forest, which grows in river-valleys and partly on watersheds, is the oak; in Siberia the copses are formed by birch-trees. The reason for such a difference lies in the severe winters, which make it impossible for the oak to grow in Siberia. Besides, one must note that absence of forest is a function of correlation of warmth and moisture, in passing to the East the quantity of the latter diminishing and the boundary of the steppe gradually moving to the North. Therefore the sum of heat of a locality immediately in the North of the Steppe region in Siberia corresponds to those places in Europe where the oak does not form forests or even does not grow at all. In some places in Europe the oak (as for instance near Kiev), or in Siberia the birch (near Tomsk) forms a region of dense forest. In other places districts of steppe-biotops are met within the immediate neighbourhood of the Taiga. The fauna of the forest-steppe does not present anything characteristic: it is a mixture of forest and steppe forms in its various ecological districts.

To the South of the forest-steppe zone comes the steppe zone, which may be subdivided into the more Northern mixed grassy steppe and the Southern dry-gramineous Artemisia steppe. This zone extends to the South of European Russia and in Siberia to the Altai, then in islands further to the East, forming large districts around Minusinsk, in the Irkutsk region and in Transbaicalia. Separate elements of steppe fauna are noticeable even in the environments of Jakutsk at 64^0 N. L.

The greater part of steppe soils (black earth — tshernosjom) is tilled and produces the principal mass of cereals. Therefore here the injurious insects of crops are particularly important. The steppes of European Russia are not homogeneous in distribution; one must distinguish, 1) a rather cold Northern tshernosjom region between the Volga and Tambow, 2) a warmer Middle tshernosjom region with a more moist western Ukraine district, the sugar-beet region, and a drier Eastern region, and 3) the Southern dry steppe with the isolated district of Kuban with considerable humidity again.

In the Northern tshernosjom subzone, — to be more exact, in the most Southern part of the forest zone — the presence of *Locusta migratoria* is characteristic, at times appearing in masses; *Hydroecia* is harmful only in this region. Especially fatal for farming is here *Oscinella frit*, which does not permit the cultivation of spring wheat and barley and is therefore one of the causes of uniformity of crops in this region.

In the middle-tshernosjom subzone are characteristic: the "crop-beetle" *Anisoplia*, in dry years *Feltia segetum*, the same species as in the North, but damaging in two instead of one generation, the summer one the sugar-beet, the autumn one the winter crops as in the North. Here the principal damage is done by the "Hessian fly" *Mayetiola destructor;* among locusts is characteristic *Calliptamus italicus;* in some years appear in masses the "meadow moth" *Loxostege sicticalis*, attacking sugar-beet and other non-gramineous crops (this occurs also in the next region); on the sugar-beet lives *Bothynoderes punctiventris*. The caterpillar of *Aporia crataegi* is one of the chief injurious insects in gardens (it is also harmful more to the North). Young forests are injured by *Melolontha hippocastani*. Injurious insects which this district has in common with the more Southern region are the bug *Eurygaster integriceps* and the stem saw-flies *Cephus* and *Trachelus*.

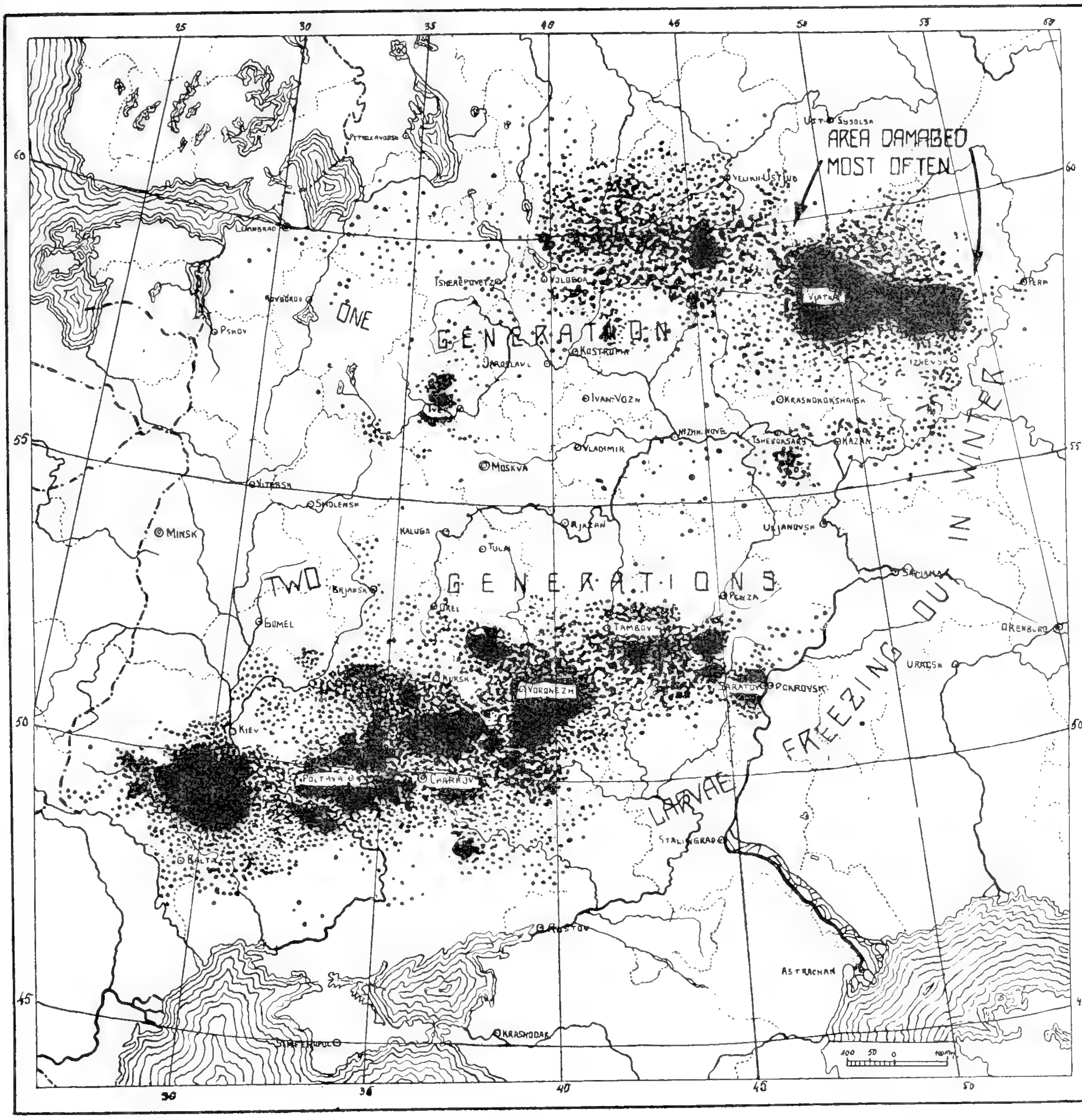
Only in the Southern region do we find several species of *Tenebrionidae*, the damage done by which is noticeable in drier years; the European corn-borer, *Pyrausta nubilalis*, on corn and millet, the now almost extinct *Oria musculosa*, whose caterpillar lives in the stems of cereals, two species of *Crambus*, which devour the hayfields, the Carabid *Zabrus tenebrioides* and some species of the longicorn-beetles of the genus *Dorcadion*. The last mentioned injurious insects are connected with the imperfect system of agriculture in our South (wheat following wheat).

In Siberia the colder part of the forest steppe region is the centre of increase of the Siberian locusts *Gomphocerus sibiricus*, *Chorthippus scalaris* and some others. Larvae of Elaterids and of the lamellicorn *Rhizotrogus solstitialis* also are very serious pests. Their harmfulness is connected with an imperfect fallow system of agriculture.

The Mediterranean Subregion enters Russia in the form of two zones — the Mediterranean proper, represented by small districts in the Crimea and in Transcaucasia, and a desert widely extending into the Aral-Caspian lowlands and into Eastern Transcaucasia.

Of the injurious insects of the desert zone the most essential are the Asiatic locust *(Locusta migratoria)* in the swamps of large rivers, and the Moroccan locust *(Dociostaurus maroccanus)* in desert places in Turkestan and Transcaucasia, and somewhere also *Calliptamus italicus*. It is of interest to note the harm which Tettigoniids of several species do around the Eastern part of the Caucasian mountain chain, sucking out the unripe seeds of cereals. The bug *Eurygaster integriceps* is injurious in many regions of that zone also. The melon fly *Myiopardalis pardalina*, which is known further to the South in Persia, India and Irak, has greatly diminished the cultivation of melons in Transcaucasia and N. Caucasus. Much trouble is caused by cotton pests, amony which *Heliothis obsoleta* is the chief one. Fortunately the pink bollworm *(Platyedra gossypiella)* has not been introduced to us. In vine regions much anxiety in felt about the leaf-roller *Polychrosis botrana* and *Phylloxera*, which is chiefly injurious in Western Trans-

caucasia, but has been exterminated in the Crimea. *Theresia ampelophage* and two species of *Otiorrhynchus* are very noticeable in the Crimea and in Novovossijsk region in the N. Cancausus.



Diagrammatic map of the damage done by *Feltia segetum in 1922—27*. Each dot corresponds to 100 hectares of winter crops destroyed. Two separate areas: in the North the cutworm has one generation and in the South two. Hard frosts with little snowfall appears to be the reason for the absence of damage in the East. Most constant is the damage on the light sandy soils of the North-east. The axis of high barometrical pressure (approximately the direction Poltava-Saratow) marks the chief area of damage in the South.

The Central Asiatic Subregion may be very roughly and approximately divided into a Mongolian Desert steppe and Mountain zone. The mountain zones of the Caucasus and even of Europe are in reality impoverished continuations of this zone. Pamir, perhaps, is its most varied centre.

The East-Asiatic Subregion enters into Russia only with its outlying districts, the valleys of the Amur and Ussuri. This subregion more than

others has preserved its primary tertiary character with a large number of species of trees, which have disappeared in the remaining Palaearctic Region, making it like the Atlantic States of N. America The fauna is rich in endemic species; the influence of the Indian region is felt, especially in China, where it would be difficult to trace exactly the boundary between the two regions. Its injurious insects are also endemic; for instance, the tree grasshopper *Prumna primnoa,* which devours crops and vegetables grown near forests, and the "Army worm" *Cirphis unipuncta,* which is well known in N. America. Further to the West this region is represented by an elevated district along the Himalayas, and still further West by two isolated islands along the Southern coast of the Caspian Sea and the East coast of the Black Sea (Batum). The first of them has a fauna rich in endemics. The second is impoverished and moreover inundated by Mediterranean elements.

Thienemann, discussing in one of his very interesting papers the question of biocoenosis, emphasizes that each highest complicated organic unit is somewhat greater than the sum of its constituent parts. Often, when characterizing the animal population of some zone, well defined by plants, we find a difficulty in naming characteristic animals, as they occur also in an adjoining zone. I think this is due rather to our ignorance than to the vagueness of nature. We still behave as faunists who value a fauna according to the number of discovered species. Such valuation, of course only a quantitative one, does not give any approximation to the dynamics of life — the final aim of ecology. The increase of injurious insects is an approach to such a quantitative valuation, though an inexact one. In searching for a quantitative centre of species, I have often tried to show that a zone is something more than a medley of its component biotops or a sum of the species living in it.

Über das Mimikryproblem und seine Schwesterprobleme.

F. Heikertinger, Wien.

Der Vortrag zerfällt in zwei Teile. Im ersten Teil gibt der Vortragende eine Übersicht der Kategorien der biologisch bedeutsamen Tiertrachten; im zweiten Teil wird die Kritik der Hypothesen behandelt.*)

I. Teil: ÜBERSICHT DER KATEGORIEN.

A. UMGEBUNGSTRACHT.

(Sympathische Färbung, General resemblance to the environment).

1. Protektive Umgebungstracht (entweder konstant oder variabel).

Schöne Beispiele bedingt variabler Umgebungstracht sind die Färbungsaberrationen der algerischen Wüstenheuschrecken *Eremobia cisti* F. und *Helioscirtus capsitanus* Bonn., die sich zur Zeit der Häutungen genau den speziellen Bodenfärbungen anpassen können (Farbtafeln Vosselers, 1902). — Verbergende Allgemeinfärbung ist häufig auf Schmetterlingsflügeln, bei Nachtfaltern (Heteroceren) auf der Oberseite speziell der Vorderflügel; doch zeigt eine farbige Bildtafel, daß gerade die gefährlichsten Massenschädlinge — z. B. die Nonne, *Lymantria monacha* L., und der Schwammspinner, *L. dispar* L., — keine solchen Schutzfärbungen besitzen. — Die unansehnlichen Färbungen der Tagfalter (Rhopaloceren) liegen zumeist auf der Unterseite der Flügel, da diese Seite bei der Ruhestellung sichtbar ist; auffälligerweise reicht die Schutzfärbung auf dem Vorderflügel hier of gerade nur so weit, als der Vorderflügel in der vollen Ruhelage noch sichtbar ist (bei den *Pyrameis* spp. z. B. ist dies nur ein Saumstreifen am Vorderrande).

2. Aggressive Umgebungstracht.

Beispiel: Bild des wüstenfarbigen Löwen, *Felis leo* (wobei unbeachtet bleibt, daß der Löwe nächtlich jagt und seine Färbung kaum eine Rolle spielt).

B. MIMESE (Mimesis).

3. Protective Mimese.

a) *Phytomimese* (protektive).

Die Ähnlichkeit mit Pflanzenteilen ist die häufigste Mimese. Sie ist nicht immer scharf von der "Umgebungstracht" zu trennen, wie z. B. bei der javanischen Heuschrecke *Satrophyllia femorata*, die, eng an ein flech-

*) Im folgenden Bericht werden aus dem mit reichlichen Lichtbildern Vorgeführten nur einzelne besonders bemerkenswerte Fälle heraushebend erwähnt.

tenbesetztes Aststück geschmiegt, sich von diesem kaum abhebt (schöne Photogramme von H. Karny). — Die Heuschrecken der Gruppe der Pseudophyllinen ahmen mit ihren Flügeln nicht nur grüne oder braune Blätter nach, sondern auch Blätter, deren Endhälfte braun abgedorrt oder weiß verpilzt ist; seltsame Ausschnitte oder kleine Löcher ähneln Insektenfraßspuren u. dgl. (Farbtafel *Pterochroza* spp. von Brunner v. Wattenwyl, 1883; "hypertelische" Nachahmung Brunners). —

Flügellose Heuschrecken aus verschiedenen Gruppen (Phasmiden, Proscopiden) sind übertrieben lang, stabförmig gebaut, sehen Zweigen ähnlich. Ein vergleichender Blick zeigt jedoch, daß diese Extremformen plumpere Verwandte besitzen, welche viel häufiger sind als die angeblich besser ausgestatteten Astnachahmer. — Afrikanische Cicaden (*Flata* sp.) ahmen, reihenweise an Zweigen sitzend, angeblich zu ihrem Schutze gelbrote Blüten nach (Hinde, 1902). — Berühmt sind die Bilder der indischen Blattschmetterlinge der Gattung *Kallima;* die Tiere sind in der Regel auf dünnen, beblätterten Zweigen sitzend dargestellt; das Hinterflügelschwänzchen berührt den Zweig wie ein Blattstiel, die Blätter haben genau Größe, Form und sogar Färbung (!) des Falters. Diese Bilder sind unrichtig, unnatürlich; die *Kallima*-Arten setzen sich regelmäßig mit dem Kopf nach unten an Baumstämme, schlagen gleich unseren Tagfaltern oft die oberseits bunten Flügel auseinander und sind recht auffällig. (Photogramm von E. Green, 1908).

b) Zoomimese (protektive).

Beispiele: Myrmekophile Käfer, die die Gestalt und Färbung ihrer Wirtsameisen "nachahmen" und angeblich deshalb unbeachtet und unbehelligt unter diesen leben. *Mimeciton, Ecitomorpha, Ecitophya, Mimanomma* etc.; Bildtafeln Wasmanns).

c) *Allomimese* (protektive).

Erdlebende Käfer ähneln zuweilen Erdklümpchen, Schaf- oder Ziegenkot u. dgl. Mit gerollten Flügeln sitzende kleine Motten ähneln Vogelkot.

4. Aggressive Mimese.

d) *Aggressive Phytomimese.*

Fangheuschrecken, Mantiden, ähneln Blattgebilden und werden unter dem Schutze dieser Ähnlichkeit von ihren Beutetieren nicht bemerkt (z. B. *Toxodera).* Andere Mantiden ähneln farbigen Blüten *(Idolum diabolicum, Hymenopus bicornis)* und locken Insekten an (Übergang zur Locktracht).

e) *Aggressive Zoomimese.*

Ein räuberisches Tier kleidet sich in die Tracht eines von seinen Beutetieren unbeachtet bleibenden Tieres; z. B. ein Ameisenräuber ähnelt selbst Ameisen, um sich diesen unbeachtet nähern zu können (Larve der Wanze *Nabis lativentris?).* — G. Breddin (1896) gibt Bilder afrikanischer Raubwanzen der Gattung *Phonoctonus,* die harmlosen Wanzen der Gattung *Dysdercus* äußerst ähnlich sehen, und meint, die Raubwanzen gebrauchten ihre Ähnlichkeit, um die *Dysdercus*-Arten zu beschleichen. — Parasitische Fliegen der Gattung *Volucella* ähneln Hummeln, *Bombus (Bremus),* angeblich, um sich unerkannt in die Hummelnester einschleichen und dort ihre

Eier ablegen zu können. (P. Speiser u. a. haben nachgewiesen, daß für diesen Zweck gar keine Ähnlichkeit notwendig ist.)

f) *Aggressive Allomimese.*

Hinterindische Spinnen, die in ihrem kleinen Gespinst auf Blättern lauern, ähneln Vogelkot und sollen hierdurch Insekten anlocken (Übergang zur Locktracht).

C. UNGEWOHNTTRACHT (Misoneismus).

Eine Färbung oder Gestalt, die einem Feind unbekannt ist, kann sein Mißtrauen, Zögern, ja sogar seine Furcht erregen. Experimente erweisen dies. Wenn z. B. ein Vogel ein buntes Insekt, das er nie gesehen hat, mißtrauisch betrachtet und ungefressen läßt, so liegt offenkundig Mißtrauen, Vorsicht, Misoneismus, als eine Wirkung der Ungewohnttracht vor. — (Wer die Ablehnung eines bunten Tieres als Wirkung der "Warntracht" erklären wollte, müßte nachweisen oder doch wahrscheinlich machen, daß das Beutetier dem Feind schon früher begegnet ist, angegriffen, versucht und wegen abwehrender Eigenschaften tatsächlich verschmäht wurde).

D. SCHRECKTRACHT (Terrifying Appearance).

1. Nichtmimetische Schrecktracht.

Beispiel: Falter der Gattung *Catocala* mit schutzfarbigen Vorderflügeln, die bei einem Angriff die grellfarbigen Hinterflügel plötzlich enthüllen und damit den Feind angeblich erschrecken.

2. Mimetische Schrecktracht.

Beispiel: Der Falter *Smerinthus ocellatus* besitzt schutzfarbige Vorderflügel; wird er angegriffen, so enthüllt er zwei drohende Augenflecke auf den Hinterflügeln, welche zusammen mit dem Körper des Falters einen Raubtierkopf (!) vortäuschen sollen. — Die Raupe von *Chaerocampa elpenor* besitzt hinter dem Kopfe zwei Augenflecken, welche den Kopf einer gefährlichen Schlange (!) vortäuschen sollen. (Eine Farbtafel aus einem Schmetterlingswerk zeigt indes, daß es in der Verwandtschaft zahlreich Raupen gibt, die keine solchen Augenflecken und wieder andere, die solche Flecken auf dem ganzen Körper haben!)

E. WARNTRACHT.

Beispiele allbekannt. Insbesondere die Kontrastfärbungen „gelb-schwarz" (z. B. Erdsalamander, Unke, Wespen etc.) und „rot-schwarz" (Zygaenen etc.) gelten als „warnend", das heißt, eine widrige Eigenschaft (Ekelgeruch, Ekelgeschmack, scharfe oder giftige Körpersäfte, Giftstachel od. dgl.) anzeigend.

Beispiele der *gemeinsamen Warntracht* (Common Warning Colouration, Synaposematic Colouration, fälschlich „Fritz Müller'sche Mimikry" genannt), sind die „Mimikryringe" grellfarbiger, angeblich ungenießbarer Schmetterlinge, z. B. der Heliconiinen, Ithomiinen usw. Südamerikas.

F. MIMIKRY (nachgeahmte Warntracht)

1. „Nachahmung" wehrhafter Insekten.

„Nachahmung" stechender Hymenopteren.

a) *Wespen, Bienen* u. dgl. — Bekannte Beispiele unter den Lepidopteren: *Trochilium apiforme, Hemaris scabiosae;* unter den Dipteren beson-

ders Syrphiden *(Syrphus, Eristalis, Volucella, Sericomyia, Milesia* etc., besonders interessante Formen aus den Gattungen *Baccha, Microdon* und *Cerioides* hat jüngsthin Sack von den Philippinen bekannt gemacht), ferner Asiliden, Mydaiden und andere.

Unter den wespennachahmenden Coleopteren (Cerambyciden) zwei Typen: α) Mit gelb-schwarzer Wespenzeichnung auf den Elytren (Clytinen etc.). — β) Mit kurzen Elytren und freiliegenden Hautflügeln. Von letzterem Typ ist bekannt das Bild des borneanischen Mimikry-Paares *Mygnimia aviculus* Sauss. (Wespe) und *Coloborhombus fasciatipennis* Waterh. (Käfer).

b) *Ameisen.* — (Hierher gehört nur jene Ameisenähnlichkeit, die gegen insektenfressende Vertebraten schützen soll, denn nur diese ist „nachgeahmte Warntracht". Die Ähnlichkeit von Ameisengästen mit ihren Wirtsameisen — soweit es eine solche gibt — ist Zoomimese.) Beispiele von Ameisenmimikry: Amerikanische Spinnen *(Synageles, Synemosyna);* Hemipteren (z. B. die Larve von *Nabis lativentris);* Grillen (z. B. *Phylloscirtus),* Larven von Blattheuschrecken *(Eurycorypha [Myrmecophana] fallax),* von Mantiden usw.; ferner Käfer (Anthiciden, *Stilicus* etc.), Cicaden (Membraciden) usw.

c) *Nachahmung anderer vermeintlich wehrhafter Tiere.*

Larven der Heuschreckengattung *Leptoderes (Trochalodera, Condylodera)* ähneln Cicindeliden der Gattung *Collyris.* Die Ähnlichkeit ist groß; doch ist kein Grund zu sehen, weshalb *Collyris* geschützt sein sollte.

2. „Nachahmung" schlecht riechender, schlecht schmeckender oder sonstwie geschützter Tiere.

Coccinelliden gelten als geschützt durch ihr „Ekelblut"; sie werden von Blattiden „nachgeahmt" (Farbtafel Shelfords, 1912). — Die Chrysomelidengattungen *Diabrotica* und *Lema* zeigen überaus ähnliche Farbkleider (Farbtafel Gahans, 1891); die Annahme, daß die Gattung *Diabrotica* „ungenießbar" sei, ist aber durch nichts begründet, ja durch Erfahrung widerlegt; überdies zeigt sich die Ähnlichkeit in Details — z. B. in der Färbung einzelner Fühlerglieder — die sicher nicht Objekt einer „Auslese" sind.

Am berühmtesten ist die Schmetterlingsmimikry, die auf der auch heute noch ganz unbewiesenen Voraussetzung ruht, daß gewisse Schmetterlingsgruppen ihren Feinden „schlecht" schmeckten. Die Heliconiinen, Ithomiinen usw. Südamerikas werden von Pierinen *(Dismorphia* etc.) „nachgeahmt" (Farbtafel Bates's, 1861). Farbtafeln Dixeys (1896) zeigen, wie sich aus dem ursprünglichen Weiß der Pierinen die Heliconiinenfärbung herausgebildet haben soll. Andere Forscher aber haben die Reihe umgedreht, haben die bunten Pierinen für die ursprünglicheren Formen und das Weiß für einen Endpunkt der Farbenevolution erklärt. Mit dieser Auffassung stimmt überein, daß die Männchen, deren Färbungstyp zumeist der höher entwickelte ist, vielfach mehr Weiß auf den Flügeln tragen als die Weibchen, die viel buntfarbiger sind *(Mylothris).*

Die Danainen und Acraeinen ähneln oft Papilioninen, Nymphalinen usw. Berühmt ist der afrikanische *Papilio dardanus (merope)* mit mehreren Weibchenformen, die verschiedene Danainen *(Danais chrysippus, Amauris*

spp.) „nachahmen“. Der Entstehung durch Auslese widerspricht hier die Tatsache, daß verschiedene „Mimetiker“ aus einem einzigen Weibchen hervorgehen.

Schließlich wird eine Auslese besonders merkwürdiger Erscheinungen im Lichtbild vorgeführt.

Bei *Precis*-Arten besteht Saisondimorphismus: die Regenzeitform ist lebhafter gefärbt, unterseits mit deutlich hervortretenden kleinen Augenflecken; die Trockenzeitform ist eintönig unansehnlich gefärbt, unterseits blattähnlich. Poulton (1903, Farbtafel) deutet dies so: zur insektenreichen Regenzeit sind die Falter lebhaft, setzen sich nur für kurze Zeit nieder, werden von Vögeln leicht entdeckt; hier ist es nun gut, wenn der rasche Angriff des Vogels durch die Augenflecken auf die Flügel abgelenkt wird; der Falter kann sich, wenn auch mit verletztem Flügel, in Sicherheit bringen. In der insektenarmen Trockenzeit aber fliegen die Falter selten, und für den stillesitzenden Falter ist es besser, wenn er vor dem jagenden Vogel durch gute Blattähnlichkeit geschützt ist. Daher der Dimorphismus.

Green (1908) bildet eine Wanze mit zwei schwarzen, rundlichen Flecken nahe dem Hinterende ab; auch diese sollen wirkliche Augen vortäuschen und den Angriff auf einen minder lebenswichtigen Körperteil ablenken. Gleiches gilt von Schmetterlingen (Lycaeniden, *Thecla)*, deren merkwürdige Zeichnung auf der Flügelunterseite und fadenförmige Schwanzanhängsel der Flügel einen zweiten Kopf mit Fühlern am Hinterende vortäuschen. (Zweiköpfige Schmetterlinge; Farbtafel von Mortensen).

Einen sitzenden Nachtfalter *(Suana concolor)* aus Java hält Mortensen für den Nachahmer einer Spitzmaus *(Sorex)*. Eine grüne, seitlich blattähnlich flachgedrückte Membracidenlarve hält Poulton (1891) für die Nachahmerin einer Blattschneider-Ameise *(Atta)*, die eben ein grünes Blattstück trägt. Haviland und Poulton (1925) bilden Raupen ab, deren eine eine Spinne — ein ungeschütztes Tier! — „nachahmt“, während eine andere einen geäugten Schlangenkopf, eine dritte sogar den aufgeblasenen Hals einer Cobra kopieren soll. Diese Schlangennachahmer sind kaum so lang wie ein kleiner Finger!

An den Kopffortsätzen einiger Leuchtzirpen (Fulgoriden, *Laternaria)* hat Poulton (1924) eine verblüffende Ähnlichkeit mit einem Alligatorkopf entdeckt, die er Affen usw. gegenüber für schützend wirksam hält. Der vorgetäuschte Alligatorkopf ist nicht länger als das letzte Glied eines Zeigefingers.

II. Teil: KRITIK DER HYPOTHESEN.

Es darf nicht vergessen werden: Die vorgeführten Tiertrachtkategorien sind hypothetische Konstruktionen. Objektiv liegen nur Ähnlichkeiten für das menschliche Auge vor; ob aber diesen Ähnlichkeiten eine biologische Bedeutung zukommt oder nicht, darüber kann nur die Erfahrung an Tatsachen entscheiden. Nur zwei der Kategorien sind experimentell sicher erwiesen oder unmittelbar einleuchtend:

1. Verbergetrachten (Umgebungstracht und Mimese). — Es ist ohne weiteres denkbar, daß ein unauffällig gefärbtes Tier von einem nicht suchenden Feind öfter übersehen wird als ein auffälliges.

2. Ungewohnttracht. — Erfahrung erweist, daß insbesondere intelligentere Feinde, z. B. Vögel, ihnen unbekannte, auffällige Tiere mit mißtrauischer Vorsicht, zuweilen sogar mit Furcht behandeln und ungefressen lassen (Misoneismus). Dieses Mißtrauen schwindet bald durch Gewöhnung.

Bei der Kritik der Tiertrachthypothesen muß ich hier Zeitmangels halber die bedeutungsvolle logisch-theoretische Seite ganz außeracht lassen. Zwei persönliche Fragen will ich kurz beleuchten:

1. Wie bin ich dazu gekommen, mich mit dem Mimikryproblem überhaupt zu beschäftigen?

2. Was ist die Ursache, daß meine Untersuchungsergebnisse von denen anderer Forscher vielfach abweichen?

Ich bin ohne vorgefaßte Absicht durch Tatsachenerfahrungen an das Mimikryproblem geführt worden. Jahrelange Untersuchungen hatten mir gezeigt, daß die phytophagen Käfer hinsichtlich ihrer Ernährung spezialisiert sind. Jede Art hat bestimmte Nährpflanzen; alle anderen Pflanzen nimmt sie in der Regel nicht an. Die natürliche Geschmacksspezialisation und damit die Nahrungswahl eines Tieres wird durch „Schutzmittel" in oder an der Pflanze nicht erklärt; ihr Wesen liegt im Tier. Gegen ihre wirklichen speziellen Feinde besitzt keine Pflanze wirksame „Schutzmittel"; gegen Tiere aber, in deren Nahrungskreis die Pflanze normal nicht fällt, braucht sie keine „Schutzmittel", weil diese Tiere die Pflanze nicht oder nur ausnahmsweise angreifen. Wo aber kein Angriff erfolgt, ist kein „Schutz" nötig.

Dieselben Grundprinzipien gelten — mutatis mutandis — für die karnivoren Tiere. Diese Einsicht, auf das Mimikryproblem angewendet, lieferte neue, bisher kaum beachtete Gesichtspunkte. Die bisherige Mimikryliteratur, mit wenigen Ausnahmen, geht aus von der einseitigen Betrachtung des mimetischen Tieres und seines Modells. Diese beiden werden genau beschrieben, abgebildet, bewundert. Ihre Eigenschaften werden anthropomorphistisch gewertet unter der naiven Voraussetzung, was dem Menschen stinkend, ekelhaft schmeckend sei, müsse es in gleicher Weise auch für „die Feinde" sein. „Die Feinde" sind ein verschwommener, reich mit menschlichen Gefühlen ausgestatteter, unwirklicher Begriff.

Ich stellte fest, daß in Wirklichkeit die „Feinde" der Hauptangelpunkt des ganzen Mimikryproblems sind. Sie sind es, die die Auslese besorgen; von ihren Eigenschaften und ihrer Geschmacksrichtung allein hängt es ab, welche Formen und Eigenschaften in Wirklichkeit ausgelesen werden. Da jedes Tier nun seinen besonderen Spezialgeschmackskreis besitzt, kann von „Schutzmitteln" im allgemeinen Sinne überhaupt nicht gesprochen werden. Die Grundlage aller dieser Probleme mußte daher sein:

Welches sind die Feinde der mimetischen Tiere? — Wie heißen sie? — Wie viele Arten kommen in Betracht? — Was fressen sie im Freileben? — Zeigt ihre Nahrungswahl, daß sie wirklich von dem abgewehrt werden, was uns Menschen ekelhaft und stinkend erscheint? — Vielleicht urteilen sie ganz anders als der Mensch? — (Erinnern wir uns an Aas- und Exkrementenfresser, die von den für uns ekelhaften Dingen weither angelockt werden!).

Die Besonderheit meiner Arbeitsrichtung bestand darin, daß ich den bisher kaum ernstlich beachteten Begriff „Feinde" als den wichtigsten Be-

griff des Problems aufgestellt habe. Von der vorurteilslosen, kritisch eingehenden Untersuchung der Feinde mußte die neue, gründliche Revision des Mimikryproblems ausgehen.

Zu dieser Untersuchung standen drei Wege offen:

1. Beobachtungen freilebender Tiere.
2. Versuche mit gefangenen Tieren.
3. Mageninhaltsuntersuchungen.

Von diesen dreien wird die Beobachtung immer dürftig bleiben; der Versuch wird immer mit teilweise unnatürlichen Bedingungen arbeiten. Eine klare, sichere, reichliche einwandfreie Auskunft über die richtige Freilandnahrung eines Tieres erhalten wir nur, wenn wir hinreichend viele Exemplare im Freiland rasch töten und den Inhalt des Verdauungstraktes untersuchen. Denn es muß gelten: Was ein Tier verzehrt hat, das muß sich in seinem Magen vorfinden, und umgekehrt: Was sich im Magen eines Tieres vorfindet, das muß von dem Tier freiwillig gefressen worden sein, das kann also nicht vor ihm „geschützt" gewesen sein. Von den Ergebnissen dieser Untersuchungen hängt Sein oder Nichtsein der Warntracht- und Mimikryhypothesen ab.

Ich kann in der kurz bemessenen Zeit leider auf keine Einzelheiten dieser Arbeitsweise eingehen; nur einige wenige herausgegriffene Proben kann ich vorführen.

Man hat auf anthropomorphistischer Basis angenommen, der Giftstachel der akuleaten Hymenopteren, der Wespen, Bienen und Ameisen, müsse ein „Schutz" gegen „Feinde" sein. Welches sind aber die wirklichen natürlichen Feinde der Wespen und Bienen? Sicherlich sind es in erster Reihe jene Vögel, die hauptsächlich auf fliegende Insekten Jagd machen; also Fliegenschnäpper, Bienenfresser, Würger u. dgl. Was findet sich nun in den Magen solcher Vögel? Fehlen die bestachelten Hymenopteren wirklich darin?

Diese Fragen sind tatsachengemäß beantwortbar und die reiche Literatur über Mageninhaltsuntersuchungen gibt uns die klare, sichere Antwort. Ich weise nur auf die umfangreichen Listen europäischer Forscher wie W. Baer, E. Csiki, E. Eckstein, K. Loos, N. Passerini und E. Cecconi, A. Reichert und E. Rey, G. Rörig u. v. a., sowie amerikanischer Forscher des U. S. Department of Agriculture, wie W. L. McAtee, F. E. L. Beal, S. Judd, E. R. Kalmbach, E. A. Chapin u. a. hin. Für Indien haben C. W. Mason und H. Maxwell-Lefroy, sowie E. A. d'Abreu, für Australien J. B. Cleland, für die Bismarck-Inseln F. Dahl, für Südafrika G. A. K. Marshall mehr oder weniger ausführliche Listen über Vogelmageninhalte veröffentlicht.

Aus diesen Listen ergibt sich: Die Vögel, die fliegende Insekten jagen, machen keinen Unterschied zwischen akuleaten und nicht-akuleaten Hymenopteren, sie beachten den Wehrstachel der Wespen und Bienen nicht. Ich habe den Nachweis hierfür in meinen Arbeiten geführt; hier führe ich als charakteristisches Beispiel nur eine tabellarische Speisekarte der nordamerikanischen Tyranniden vor (Lichtbild), deren Name „Flycatcher" berechtigt in „Waspcatcher" umgewandelt werden könnte.

Daß die Sage von dem Geschütztsein der Ameisen immer noch da und dort gläubig wiederholt wird, ist kaum zu verstehen. Was sollte ein Vogel an einer Ameise, die er mit hornigem Schnabel erfaßt, tötet und ver-

schluckt, zu fürchten haben? Tatsächlich erweisen Mageninhaltsuntersuchungen ebenso wie Versuche einwandfrei, daß Ameisen geradezu eine Lieblingsnahrung der Vögel sind, daß sie keinerlei „Schutz" genießen und daß daher auch eine Ähnlichkeit mit ihnen keinen Schutz gewähren kann. Manche Tiere nähren sich bekanntlich größtenteils von Ameisen (Erdspechte, Wendehals, tropische Ameisendrosseln usw.).

Neben dem Giftstachel gelten „Ekelgeruch" und „Ekelgeschmack" als wirksame „Schutzmittel". Ein bekanntes Beispiel angeblich geschützter Tiere ist die Käferfamilie der Coccinelliden, die aus den Gelenken ein „Ekelblut" austreten lassen. Ein weiteres Beispiel sind die ein übelriechendes Sekret absondernden Stinkwanzen, Hemiptera heteroptera. Ihr Ekelgeruch wird aber von Vögeln und anderen Insektivoren gar nicht beachtet; die Heteropteren, insbesondere die großen, stinkenden Pentatomiden werden sehr gerne gefressen. B e a l (1908) sagt von ihnen nach Untersuchung von Tausenden von Vogelmageninhalten, wenige Insekten seien in den Magen so vieler Vogelarten und Vogelindividuen gefunden worden wie diese.

Ich führe nur ein charakteristisches Beispiel an: das Bild, das die Untersuchung von 70 Magen des nordamerikanischen *Vireo huttoni* gibt. Nach C h a p i n (1925) sind 13.25% der Gesamtnahrung Käfer, darunter sind ⁵/₈ Coccinelliden (8.12% der Gesamtnahrung!); Coccinelliden fanden sich fast in der Hälfte der untersuchten Magen. Hemiptera bilden fast 46% der Gesamtnahrung, darunter sind fast die Hälfte Stinkwanzen, *Pentatomidae.*

Auch die Käfergruppe der Carabiden soll durch ihr übelriechendes Sekret vor ihren Feinden geschützt sein. Mageninhaltsuntersuchungen erweisen, daß dies nicht zutrifft. Die Carabiden werden ohne Beachtung ihres Ekelgeruchs verzehrt; sie sind eine Lieblingsnahrung aller an der Erde jagenden Insektivoren.

Etliche Proben: In 50 Bussarden, *Buteo buteo*, fanden P a r r o t und L e i s e w i t z (1904) an Coleopteren: 14 Laufkäfer, *Carabus* spp., 6 Mistkäfer, *Geotrupes* spp., 4 Maikäfer, *Melolontha* sp. — In 13 Gewöllen eines Storches, *Ciconia ciconia,* fand B a e r (1910) 12 Hinterbeine einer Heuschreckenart, *Mecostethus,* 1 Thorax von *Agrion,* 1 Kopf von *Vespa vulgaris,* 35 Flügeldecken und 2 Halsschilde von *Carabus granulatus,* eine Fülgeldecke von *Carabus arvensis,* 37 Flügeldecken und 5 Halsschilde von *Pterostichus niger,* 3 Flügeldecken von *Broscus cephalotes* usw. — In einem Magen der kalifornischen Wiesenlerche, *Sturnella neglecta,* fand H. C. B r y a n t (1912) 2 Raupen, 44 Laufkäfer *(Calathus ruficollis),* 2 Fliegen, 1 Spinne, 13 Fliegenpuppen.

Weiter erweisen die Mageninhalte, daß die großen Dytisciden trotz ihres milchigen "Abwehrsekrets" von größeren Vögeln (Storch, *Ciconia,* Turmfalke, *Cerchneis tinnunculus,* usw.) gerne gefressen werden. Der ekelhaft stinkende Saft, den die *Silpha*-Arten bei Beunruhigung austreten lassen, hindert die Insektenfresser nicht am Fraß; ebensowenig der Ekelgeruch und das drohende Hinterleibsheben der Staphyliniden. Alle diese Tiere mit berühmten Schutzmitteln, die sich hypothesengemäß nicht in den Magen finden sollten, finden sich reichlich darin vor.

Im Gegensatz hierzu steht das auffällige Fehlen einer Insektengruppe, die nach den Hypothesen häufig in den Magen vorkommen müßte, nämlich der Schmetterlinge. Tagfalter, *Rhopalocera,* um die es sich bei der Mimi-

kry speziell handelt, finden sich fast gar keine in den Vogelmagen vor. Und doch ist die Tagfaltermimikry das Paradestück der Mimikryhypothese; wäre sie richtig, so müßten Tagfalter sogar sehr häufig in den Vogelmagen vorhanden sein.

Einige Proben: Csiki fand in 2523 Vogelmagen nur fünfmal Schmetterlingsreste, darunter keinen Tagfalter, wohl aber den berühmten Wespenmimetiker *Trochilium apiforme!* — Reichert und Rey fanden in 1980 Vogelmagen nur achtmal Schmetterlinge; nur bei einem davon ist die Notiz beigefügt: „Scheint ein Tagfalter zu sein". — McAtee (1912) schreibt: "Practically the only large body of authentic information on the natural food habits of birds is contained in the records of the United States Biological Survey. They comprise detailed identifications of the contents of more than 48,000 bird stomachs representing all families of birds and collected in hundreds of localities in the United States at all seasons. The United States has a goodly representation of butterflies, yet only five of these 48,000 stomachs contained remains of Rhopalocera." — Mason und Maxwell-Lefroy (1912) fanden in 1329 Magen indischer Vögel nur in etwa 20 Fällen bei insgesamt 9 Vogelarten Schmetterlinge; aber sie nennen unter diesen keinen Tagfalter. — Cleland (1913) fand in 257 Magen australischer Vögel nur einmal einen Tagfalter. — G. L. Bates (1911) fand in 178 Magen insektenfressender Vögel Südkameruns keinen Tagfalter. — Usw.

Man könnte einwenden, die relativ weichen Chitinteile der Schmetterlinge verschwänden früher aus den Magen als die harten Chitinteile der Käfer usw.; deshalb würden keine gefunden. Es ist zweifellos richtig, daß die harten Käferreste länger im Magen bleiben; wenn wir aber sehen, daß sich in den Magen gar nicht selten Reste von Insekten finden, die ebenso weich oder noch weicher sind als ein großer Tagfalter, z. B. Phryganiden, Psylliden, kleine Blütenwanzen, Neuropteren, Dipteren, Ichneumoniden etc., ferner Spinnen und Insektenlarven, dann wird uns klar, daß das auffällige Fehlen der Tagfalter nicht mit ihrer Hinfälligkeit allein erklärt werden kann, sondern eine andere Ursache, eben die geringe Verfolgung der Schmetterlinge, haben muß.

In gleichem Sinne sprechen die Beobachtungen im Freiland. Die Kenner stimmen überein, daß eine Jagd und Verfolgung der weithin sichtbaren Tagfalter durch Vögel in der Regel nicht erfolgt. Die gegenteiligen Erfahrungen, auf die sich einige Forscher berufen, betreffen einige wenige Vogelarten, die fliegend jagen, besonders Bienenfresser, Meropiden. Sie sind Ausnahmen.

Man hat durch Versuche erweisen wollen, daß Vögel Tagfalter fressen. Aber es ist grundsätzlich etwas ganz anderes, ob ein zahmer, nicht hungriger, beschäftigungsloser Käfigvogel sich mit halbtoten Schmetterlingen beschäftigt und sie — je nach Laune — verzehrt oder liegen läßt, oder ob lebensfrische Tagfalter im Freiland von den Vögeln gejagt werden. Daß letzteres nicht der Fall ist, erweisen die Freilandbeobachtungen ebenso wie die Mageninhaltsuntersuchungen.

Dennoch hat man, von Liebe zur Mimikryhypothese erfüllt, versucht, aus Experimenten eine Bestätigung des „Ekelgeschmacks" gewisser Falter und Faltergruppen herauszulesen.

Welch eigenartige Mißdeutungen hierbei unterlaufen können, dafür will ich — zum Schluß meiner Darlegungen — nur ein Beispiel anführen: Swynnerton hat schöne Versuche mit Blauraken, *Coracias garrula*, in Afrika angestellt. Es ergab sich, daß die als ungeschützt geltenden *Charaxes* in der Tat zuerst und in größter Zahl gefressen wurden, die als widerwärtig geltenden *Acraea*-Arten dagegen in geringster Anzahl. Also eine schöne, einwandfreie, experimentelle Stütze der bekannten Hypothesen!

Das Rätsel löst sich aber in viel einfacherer Weise sogleich, wenn wir aus einer größeren Schmetterlingsammlung eine Reihe *Charaxes* mit einer Reihe *Acraea* vergleichen. (Es genügt auch ein Blick in ein größeres Schmetterlingstafelwerk.) Auf den ersten Blick fällt uns da auf: die *Charaxes* sind große, für einen Tagfalter relativ dickleibige, saftige Schmetterlinge; die *Acraea* aber sind äußerst dürftige, kleine, dürrleibige Falterchen. Bedenken wir nun, daß die Blaurake ein großer Vogel ist (Dohlengröße), dann begreifen wir ohne Zuhilfenahme eines hypothetischen "Ekelgeschmacks", daß ein solcher Vogel nach den großen, fetten *Charaxes* greift, die kleinen, dürren *Acraea*-Arten aber verächtlich liegen läßt. Im Verhältnis zu den großen Flügeln ist der Braten viel zu klein, nicht der Mühe wert.

Nun gibt es aber andere Versuche, die mehr Licht in die prinzipielle Frage bringen, ob Vögel gegen starke, scharfe Gerüche und Geschmäcke empfindlich sind oder nicht. Man weiß längst, daß die Vögel äußerst geruchsstumpf sind; sie wittern nicht, ihre Riechorgane sind sehr schlecht ausgebildet. Sie werden auch von starken Gerüchen kaum beeinflußt. Ebenso ist ihr Geschmackssinn, verglichen mit dem des Menschen, äußerst stumpf. W. Liebmann (1910) hat Fütterungsversuche mit ekelhaft und äußerst scharf schmeckenden Stoffen — Tannin, Chinin, Pikrinsäure, Zitronensäure, Oxalsäure vorgenommen und nachgewiesen, daß die Vögel diese Stoffe, wenn sie unter ihre Normalnahrung gemischt wurden, gar nicht oder kaum beachteten. Und doch schmeckten diese Stoffe in der verwendeten Konzentration nach menschlichen Begriffen greulich und machten jede menschliche Speise ungenießbar.

Von solchen Tieren anzunehmen, sie würden durch einen für Menschen nicht oder kaum wahrnehmbaren Geruch wirksam "abgewehrt", entbehrt wohl jeder berechtigten Grundlage.

Die der Mimikryhypothese zuliebe gemachte Annahme von einem „Ekelgeschmack“ in der Insektenwelt findet nirgends eine feste Grundlage; dagegen spricht eine Fülle unbefangen beobachteter Tatsachen gegen sie. Überblickend fasse ich zusammen:

1. Es gibt eine ganze Reihe angeblich schützender Tiertrachten. Aus der nüchtern überprüften Tatsachenerfahrung aber steigen nur zwei als wirklich natürlich und beachtenswert empor:

a) Die Verbergetracht, und

b) die Ungewohnttracht.

2. Alle wirklich wissenschaftliche Prüfung der Hypothesen muß vom „Feind“ ausgehen. Dieser ist der wirklich auslesende Faktor. Menschliche Sinnesempfindungen und Beurteilungen haben in der Frage nichts zu tun, sie führen nur irre. Nur die Geschmacksspezialisation des Feindes entscheidet.

Zu ihrer Ermittlung stehen drei wissenschaftliche Wege offen:

a) Beobachtungen am freilebenden Feind.

b) Versuche mit dem gefangen gehaltenen Feind.
c) Mageninhaltsuntersuchungen im Freiland erlegter Feinde.

Von diesen haben die letzteren den größten wissenschaftlichen Beweiswert. Aus ihnen ergibt sich einwandfrei:

3. Der Giftstachel der akuleaten Hymenopteren (Bienen, Wespen, Ameisen) ist kein Schutzmittel gegenüber wirklichen Feinden. Jene Vögel, die überhaupt fliegende Insekten dieser Größe jagen, jagen und fressen auch die Akuleaten.

4. Gifte, wie das Cantharidin der Meloiden etc., scharfe und stinkende Sekrete wie das der Carabiden, Dytisciden, Silphiden, Coccinelliden, heteropteren Hemipteren usw. sind ohne merkliche Wirkung auf Insektenfresser, gewähren ihren Trägern keinen wirklichen Schutz, können daher keine Grundlage von Warnfärbung und Mimikry sein.

5. Im Spezialfall der angeblichen Schmetterlingsmimikry erweisen Freilandbeobachtungen und Mageninhaltsuntersuchungen übereinstimmend in voller Klarheit, daß Tagfalter von Vögeln im allgemeinen nicht gejagt werden. Dies gilt auch für die Tropen. Einige Vogelarten bilden hiervon eine Ausnahme. Daß diese oder irgendwelche andere Vogelarten einen Unterschied zwischen „wohlschmeckenden" und „widrigen" Schmetterlingen machen, ist durch nichts bewiesen; es ist im Gegenteile nach allen Tatsachenerfahrungen höchst unwahrscheinlich.

Diesbezügliche Fütterungsversuche ergaben, wie zu erwarten war, kein brauchbares Ergebnis. Ihre Voraussetzungen sind stets unnatürlich. Sie wurden allerdings vielfach hypothesenfreundlich ausgedeutet und für sichere Stützen der Mimikryannahme gehalten. (Ein Beispiel von Fehldeutung ist der Fall *Coracias—Charaxes—Acraea).*

Dagegen erwiesen Fütterungsversuche mit Sicherheit die außerordentliche Geruchs- und Geschmacksstumpfheit der Vögel im allgemeinen.

On Doryloxenus from Java and Wasmann's Hypothesis of the Host-Change of this genus of Beetles.

Dr. N. A. Kemner, Stockholm, Sweden.

(With 4 text-figures.)

Thirty years ago, in 1898, the well-known Father Wasmann described the new staphylinid genus *Doryloxenus* from South Africa *). The small beetles were collected by Dr. H. Brauns, who found them among the marching South-African *Dorylus*-ants, and as they were very curiously shaped, Wasmann thought it probable that they rode on the body of the ants, as certain other species of small staphylinid beetles had been observed to do.

The body of the small staphylinid was spool-shaped and pointed at both ends. The head was small and partly covered by the pronotum. The antennae were broad at the base, but further distally they become pointed and presented a rather horn-shaped appearance. Therefore Wasmann called the first species *Doryloxenus cornutus*. The legs were most curious: the femora and the tibiae were broad and flat, the feet were apparently missing entirely, but under high magnification Wasmann found that they consisted of only a single joint, which was provided with two big bristles and many thin sticky hairs, which made it possible for the small beetles to adhere to the body of their host.

In South Africa these small beetles were discovered among the *Dorylus*-ants, which go in big processions to rob other animals, often termites, and Wasmann suggested that these small beetles were derived from *Pygostenus* and other small Staphylinids, which live with the *Dorylus*-ants, riding and climbing upon them when they are moving in their processions.

A few years after the discovery of these small beetles in South Africa, two species of the same genus were found in India. But strangely enough, they were there found with termites in a termite nest. The morphological differences were very small and the body was of the same shape as in the African species. The small hairs found on the upper side of the African species were missing on the Indian forms, of which the backs were shining and polished. The curious feet of all three species were, according to Wasmann, so nearly alike that he could not find any good character by which they could be separated, and therefore he placed them in the same genus, *Doryloxenus*.

In this way it came about that there were known in the early years of the twentieth century one myrmecophilous species of this genus from

*) Wiener Ent. Zeit. XVII. Jahrg. 1898, p. 101.

Africa, and two termitophilous species of the same genus from India. In order to explain this curious fact, Wasmann conceived his hypothesis of a change of hosts by this genus and presented his views before the International Congress of Zoology at Bern in 1904. The title of his paper at this Congress was: „Die phylogenetische Umbildung ostindischer Ameisengäste in Termitengäste“ *).

In this paper Wasmann says that the only way in which the small *Doryloxenus* beetles could have obtained their curious modification was by a life among the *Dorylus*-ants. There they were forced to climb and ride upon the ants when these were going on their predatory expeditions.

The fact that the two Indian species were found with termites he explained by assuming that, when the *Dorylus*-ants were robbing termites, the small riding *Doryloxenus* could very easily have dropped off and been left in the termite nests. In this way they later could have become true guests of the termites.

Wasmann evades the fact that *Dorylus*-ants of this kind are totally missing in India by saying that the transition from the ants to the termites had taken place in earlier periods of the evolution of the world: in diluvial times when *Dorylus*-ants might have been in India.

This is still Wasmann's curious hypothesis of the change of hosts of the Indian *Doryloxenus*, which he propounded in 1904, and which he has repeated in his papers so often and in such definite terms that he has succeeded in making people believe that the hypothesis is true. But such an idea cannot be verified. On the contrary, I can assure you that this hypothesis, as is the case with many others which Wasmann has given us, are only speculations conceived at his desk in Europe. Father Wasmann has never seen these beetles alive in their natural surroundings. Thus his opinion about their life in the termite nest is of very little value.

During my trip to Java in 1920—1921 I had the good fortune to see these small beetles among the termites, and from my notes from Java and my research on the beetles, I can tell you something of the life of these insects and my objections to Wasmann's hypothesis.

The basis of Wasmann's hypothesis is the assumption that these beetles could never have attained their curious character in the termite's nest. In his paper at Berne, in 1904, he said that it would be as impossible for the *Doryloxenus*-beetle to have become so modified in a termite nest as for the digging mole to grow wings (l. c. 1904, pp. 440—441).

However, the small *Doryloxenus* of Java, which is the first one which has been seen alive among the termites, has the habit of riding on the head of the termite workers, as you can see from the illustration (text-fig. 1). In this curious position the small beetle will ride for a long time, and the termite worker can not remove it. When the workers are going through the small holes in the cells of the termite nest, the *Doryloxenus* do not tumble off at all, but will always remain on the termite's

*) Comptes Rendus du 6me Congrès Intern. de Zoologie; Session de Berne, 1904, p. 436.

head. The curious character of the *Doryloxenus* is very well adapted for this habit, and Wasmann's assurance that these beetles cannot have obtained their curious feet in order to live with the termites is thus entirely wrong.

The second basic factor for Wasmann's hypothesis is his assurance that the African species is more primitive than the Indian form. He uses the presence of bristles on the upper side of the body as proof of this. But if we study the feet of my new *Doryloxenus* from Java, which I call

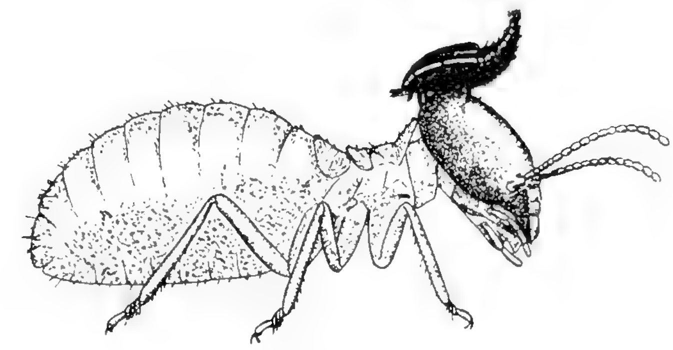


Fig. 1.

Doryloxenus triarticulatus (text-fig. 2), we will soon find that this species has 3 joints in the reduced tarsus, and not a single joint as Wasmann maintains of the African species. Fig. 2b represents a hindleg and 2c a foreleg of my *Doryloxenus*.

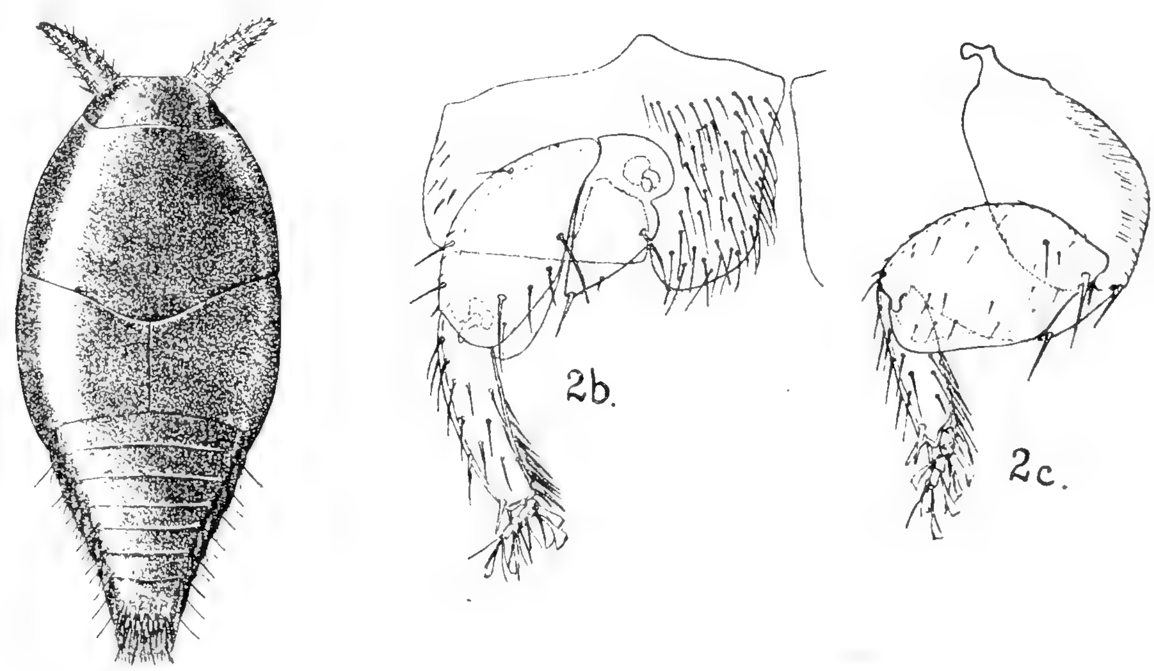


Fig. 2.

Now it is a fact that a staphylinid with 3-jointed tarsus is always more primitive than a form with only one joint, and Wasmann's view of this problem is thus also erroneous.

When we further think of the curious fact that Wasmann, in order to support his hypothesis for which he has no other evidence, is compelled to assume that marching *Dorylus*-ants have been in India in earlier times, I can assure you that this hypothesis of the Indian *Doryloxenus* in the termite nest having been derived from the ants, is utterly valueless. The transmission of these small beetles could better be said to have taken place in the opposite direction. But of what value are hypotheses of this kind, when the affinity of the staphylinids is so little known?

In summing up my objections to Wasmann's hypothesis concerning the change of hosts of the Indian *Doryloxenus*, I arrive at these three conclusions:

1. *Doryloxenus triarticulatus* Kemner from Java is very suitably adopted for its life among the termites, where I found it riding on the head of the termite workers.
2. It has a reduced, but three-jointed tarsus and is thus more primitive than the African species which, according to Wasmann, has a single-jointed tarsus.
3. *Dorylus*-ants marching in procession on the ground have never been found in India, and there is no evidence that they have ever existed there.

Chemical Methods of Insect Control in U. S. S. R.

I. A. Parfentjev, Privat-Docent, University of Moscow, Entomologist of the Insecticide and Fungicide Research Laboratory, Moscow, U. S. S. R.

The control of crop-pests in U. S. S. R. has made great strides during the last ten years: scientific research on injurious insects and on methods of their control has increased; practical measures have been organised on a large scale. The control work itself has taken definite form: we have passed, of late, to the almost exclusive use of chemical control methods against pests and plant diseases.

The control of mass ("first class") pests: locusts, suslik *), and pests of local importance is effected by means of chemical methods under the direction of Stations for Plant Protection, and under the general management of the Bureau for Plant Protection of the People's Commissariat for Agriculture of each separate republic of U. S. S. R. Experimental study of insect-pests and of methods of pest control is also carried out by the district stations for Plant Defense.

The chemical method of control is studied under the general supervision of the Moscow Laboratory for Insecticide and Fungicide Research of the People's Commissariat for Agriculture. This Laboratory, in addition to research work, organises expeditions for the execution of special tasks, such as: an aeroplane expedition for locust control, an expedition for the control of suslik, etc.

The principal business of the Laboratory is to carry on a detailed study of the problems connected with the use of insecticides, fungicides and means of control of field rodents.

In proportion to the growing use of chemical methods of pest control, the consumption of insecticides in the Union has considerably increased.

The following table shows the consumption of the principal groups of insecticides during the last decade:

Quantity of Insecticides consumed (in tons).

croup	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926
Arsenical compounds . . .	42	—	25	—	105	1284	847	940	824	688
Carbon bisulphide . . .	24	—	5	—	187	305	565	647	1208	617
Others: Sulfur .	—	—	—	—	—	—	—	—	—	120
Baryum chlorate	44	—	—	—	—	908	—	—	815**)	417**)
Tobacco dust. .	...	—	--	·	—	80	150	220	330**)	470**)
Green (potassium) soap, etc.	—	—	—	—	—	—	—	9	87**)	101**)

*) South-Russian marmot.

**) The figures marked with 2 stars show the consumption of the given insecticide in the Russian Sov. Fed. Soc. Republic (R. S. F. S. R.) only; the other figures show the consumption for all the Union of Republics (USSR).

The large quantity of arsenical compounds consumed in U. S. S. R. every year is due to the magnitude of our measures of insect control, including the control of *Acrididae* and that of numerous garden and orchard pests. The average yearly consumption of arsenical insecticides is about 400 tons.

As for carbon bisulphide, large quantities of this substance were used for suslik-control; only a small part of the carbon bisuphide consumed was used for the fumigation of granary pests.

Sulfur is being introduced at present for dusting the cotton plant against *Tetranychus telarius.*

Baryum Chlorate is used chiefly for weevil-control on sugar beet.

Tobacco dust is widely used; it is burned and the smoke is regarded as an efficient agent against the winged apple *Psylla mali;* tobacco dust is also partly used for preparing nicotine extracts.

Green soap, as an insecticide, is applied mostly in the control of garden and orchard pests.

After these preliminary remarks, let us consider the arsenical compounds used by us as insecticides. The following table gives the total quantities of various arsenical compounds consumed in U. S. S. R. for insecticidal purposes:

Production of arsenical compounds in U. S. S. R. for the control of agricultural pests.

Compound	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926
Sodium arsenite	32	—	10	—	945	53	364	792	479	356
Calcium arsenite	—	—	—	—	—	—	44	40	16	67
Lead arsenate .	—	—	—	—	—	—	—	21	36	90
Lead arsenite .	—	—	—	—	—	—	—	—	—	5
White arsenite .	—	—	—	—		—	—	27	56	—
Paris-green . .	10	—	15	—	791	—	39	60	237	170
Total	42	—	25	—	1736	53	447	940	824	688

It will be seen from the above table that sodium arsenite is the chief arsenical compound used by us. In the course of our practical control-work we have come to regard this salt as a cheap and highly toxic insecticide. Sodium arsenite is much used in *Acrididae*-control for the preparation of poisoned baits and for spraying. The principal insoluble compounds used by us are Paris-green and calcium arsenite; the latter has so far been produced, ex tempore, from sodium arsenite and fresh slacked lime.

The above description indicates that our choice of arsenical preparations as insecticides was dictated by the fact that our chief task was that of locust-control; therefore our principal demands were cheapness and toxicity of the preparation, and comparatively little attention was paid to its injurious action on leaves, the more so as locust-control work is often carried out among wild vegetation.

In the following table, a comparison is given of the quantities of arsenical compounds used for *Acrididae*-control, and those used for the control of garden and orchard pests; the data for the years 1917—1924

are given for all U. S. S. R., those for 1925 and 1926 are only for R. S. F. S. R.

Use of arsenical compounds against different pests.

Pest	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926
Acrididae . . .	—	—	25	-	105	1284	802	769	488	268
Garden and orchard pests	—	—	—	—	—	—	45	171	238	241

Until recently, many insecticides, including arsenical preparations, were imported from abroad.

As said before, the control of locusts and some other pests is effected by a special personel, at the expense of the State. But the population also applies the chemical method. In the first place, the population, under the direction of the District Stations for Plant-Protection, independently conducts control operations against garden and orchard pests. Consequently there are two channels of insecticide-consumption in U. S. S. R.: the State consumption for the control of mass pests (locust, suslik) and the sale of insecticides to the population. This distribution of insecticides is shown in the table below; the figures up to 1924 are for U. S. S. R.; for the years 1925 and 1926, the data for R. S. F. S. R. only were available.

Distribution of insecticides acc. to form of supply (in tons).

Name of insecticide	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926
State Supply										
Arsenical compounds . . .	42	—	25	—	105	1284	802	769	428	268
Carbon bisulphide . . .	23	—	5	...	187	305	565	600	650	303
Baryum chlorate	44	—	—	—	—	908	—	—	—	—
Others	—	—	—	—	—	—	—	—	—	54
Total	—	—	—	—	292	2497	1367	1369	1078	571
Sale to Population										
Arsenical compounds . . .	—	—	—	—	—	—	45	171	238	241
Carbon bisulphide . . .	—	—	—	—	—	—	—	47	223	117
Baryum chlorate	—	—	—	—	—	—	—	—	815	417
Tobacco dust .	—	—	—	—	—	80	150	220	330	470
Others	—	—	—	—	—			9	87	47
Total	—	—	—	—	—	80	195	447	1693	1292

The above table shows that a considerable quantity of insecticides is consumed in U. S. S. R. gratuitously, for State-control of the locusts and suslik. At the same time the quantity of insecticides sold to the population increases from year to year; this growing demand for insecticides on the part of the population is a sign of the latter's growing activity and participation in the control of agricultural pests.

As for insecticidal apparatus, knapsack sprayers are much in vogue. From the following table it is possible to judge of the types of insecticidal machinery used in U. S. S. R., the figures show the percentage of each type of machines to the total quantity of machines.

Types of Insecticidal Machinery used in U. S. S. R.

Description	% of total quantity of apparatus
Power sprayers	0.01
Traction sprayers	1.71
Pack-saddle sprayers	0.38
Battery sprayers	0.25
Compressed-air sprayers	22.82
Sprayers with diaphragm	26.62
Garden syringe sprayers	19.02
Hand sprayers	9.51
Total quantity of sprayers	80.32
Power dusters	0.01
Traction dusters	0.05
Dusters for use on horseback	0.04
Knapsack dusters	19.02
Ventilator dusters	0.38
Total quantity of dusters	19.50
Carbon bisulphide injectors	0.18
Total	100 %

METHODS OF CHEMICAL PEST CONTROL IN U. S. S. R.

The poison-bait method, as will be mentioned later, is used chiefly for locust control; here we shall speak of the use of poisoned baits for the control of other pests. In some, mostly Southern, districts, the control of *Gryllotalpa gryllotalpa* L. is often carried out by means of this method. For this purpose, maize-grain is saturated with an As_2O_3-solution and strewn about in the vicinity of the dwelling places of *Gryllotalpa*.

The poison-bait method has long been attracting the attention of our entomologists. At present, it is being studied in U. S. S. R. with the view of using it against the larvae of *Elateridae*, larvae and imago of *Tenebrionidae*, and the caterpillar of *Agrotis segetum*. Finally, in the areas where *A. segetum* appears in masses, the imagines are trapped by means of small troughs containing fermenting treacle.

The spraying method is widely used in U. S. S. R. The application of this method for locust control will be described later; here we will only mention that much spraying is done every year for the control of garden and orchard pests, as well as pests of special cultures.

Paris-green is sprayed in orchards for controlling the caterpillar of *Hyponomeuta malinellus* L. and *Malacosoma neustria* L. The spraying-liquid is prepared by adding to Paris-green a double quantity of unslaked lime; in some cases, Paris-green is sprayed together with Bordeaux mixture. Against *Laspeyresia pomonella* L. Paris-green spraying and some other measures, — such as removal of the old bark, trap-rings, removal of

fallen fruit — are used. This pest is widely spread in U. S. S. R. and causes considerable damage in some districts.

Mass analyses of Paris-green preparations, effected in the Laboratory for Fungicide and Insecticide Research, show but slight variations of arsenic-contents (from 54 to 57% As_2O_3), and contents of copper (from 30 to 32.5% CuO). The contents of water-soluble trioxide of arsenic varied from 0.5 to 2% As_2O_3.

Usually no scorching action of Paris-green on plants is observed. Some cases of unsuccessful use of Paris-green, viz. an insufficiently high mortality of the insects, were probably due to the fact that not all preparations of Paris-green give equally stabile water-suspensions. The preparations that are rapidly precipitated from their water-suspensions fall out on the bottom of the apparatus and do not give, when sprayed, the necessary insecticidal layer on the surface of the leaves sprayed.

Lead arsenate, giving stable water-emulsions, is gaining the appreciation of the Entomologists of U. S. S. R. At present lead arsenate with 30% of As_2O_5 is being tested on a large scale.

Experiments are also being carried out with the spraying of a lead arsenite containing 46.8% As_2O_3.

In the control of Aphids spraying of plants with nicotine and soap-solutions is used in U. S. S. R. We are elaborating standards of soap for insecticidal purposes, and are determining more detailedly the lethal concentrations of nicotine for our species of pests.

For controlling *Bothynoderes punctiventris* Germ. on sugar beet, spraying with baryum chlorate is widely applied. The above given table showing the quantity of baryum chlorate annually consumed in U. S. S. R. can serve to illustrate the proportions of this work, as baryum chlorate is used nearly exclusively against the pests of sugar beet.

Spraying with mineral oils, calcium polysulphides, and preparations of carbolineum have not, as yet, been very much used in U. S. S. R.

The problem of adding surface-active substances is also still in the stage of experimental investigation.

The dusting-method. — A serious study of the method was begun in U. S. S. R. comparatively recently (1923—1924). Before this time, we used sulphur-dusting chiefly against fungus diseases, and partly against mites. The technique of the dusting method has been elaborated by us chiefly for locust control, and dusting occupies at present an important position among our various anti-locust measures; this will be seen from the special chapter on *Acrididae* control in U. S. S. R. Among other cases of the application of the dusting-method we name the following:

At present, the dusting of vines with arsenical preparations is being introduced on the Caucasian coast of the Black Sea for the control of *Polychrosis botrana* (J. J. Printz 1926).

Dusting of crops against the caterpillar of *Agrotis segetum* was effected on a small scale (A. P. Ostapetz 1926).

Finally, in various parts of U. S. S. R., the dusting of vegetables with arsenical preparations against *Halticidae* and other pests is conducted as an experiment.

The fumigation method. — We apply this method in U. S. S. R. principally against granary pests. For disinfecting flour and grain we mostly use carbon bisulphide. The technique of fumigation with this gas was minutely worked out by M. Portshinsky. Carbon bisulphide fumigation is still carried out on a large enough scale; however, the inflammability of this gas led us to undertake special investigations of the gas disinfection of grain. The results of this work will be given further on in a special chapter; here we shall dwell only on our practical measures of this kind.

Where it is possible and is not against the Fire-Regulations, we fumigate flour and grain with carbon bisulphide. Empty granaries are also fumigated with carbon bisulphide, as well as sulphur dioxide; the latter gas is obtained by burning sulphur. But as many of our granaries are not sufficiently air-tight, it is often impossible to disinfect them by means of fumigation, and therefore we often have to apply mechanical cleansing of empty granaries.

Total removal of all remnants of grain and flour, spraying of all the interior of the granary with kerosene-soap emulsions and alkali-solutions, white-washing of the walls, etc., are the first steps.

For disinfecting inhabited buildings, we use as fumigant sulphur dioxide and, in a lesser degree, hydrocyanic gas.

Fumigation of plants is much less applied in U.S.S.R. Only a few isolated experiments of fumigating trees with hydrocyanic gas have been made; the chief difficulties for us, in this respect, are the absence of the necessary apparatus, and the high cost of this method.

However, the question of plant-fumigation deserves great attention in U.S.S.R., especially in the valuable Citrus plantations on the Caucasian coast of the Black Sea, where *Coccidae* are a frequent pest.

In our pratice plant fumigation is usually effected by means of tobacco-smoke. This is a very cheap method for the control of *Psylla mali* Schm., and it is widely used by the peasantry of U.S.S.R. The technique consistes in burning tobacco-dust in gardens during the night. This method is now being introduced also for controling aphids in hot-houses. I have obtained good results by the use of tobacco-dust for fumigating mosquitoes in their winter-resorts.

Among methods of gas disinfection of soil, we must mention, first, the use of carbon bisulphide against the larvae of *Melolontha melolontha* in forest nurseries; and second, against the larvae of *Polyphylla fullo* L. in vineyards. Carbon-bisulphide, as a soil-disinfectant, plays also an important rôle in U.S.S.R. in the control of *Phylloxera vastatrix*. As to other substances tested by us for soil disinfection, we mention the succenful attempt of Z. S. Golovianko (1927) to use paradichlorbenzol against the larvae of *Polyphylla fullo* L. and a small experiment by O. N. Vassin who disinfected the soil with sublimate against the larvae of flies attacking cabbage-roots.

Let us now pass to a more detailed description of some experimental work effected during the last years in the branch of chemical control of insect-pests.

STANDARDIZATION OF VARIOUS SODIUM ARSENITES.

As has already been said, sodium arsenite is widely used in our country as an insecticide. This substance does not, however, give constant and definite results. The numerous investigations of the Moscow Laboratory for Insecticide and Fungicide Research and of the Omsk Station for Plant Protection show considerable variations in the arsenic contents of sodium arsenite preparations used by us (from 29 to 82%). It was, accordingly, necessary to effect a careful study both of the techni-chemical properties of these preparations and of their toxic action, this investigation including also the problem of standardization of sodium arsenite.

The toxic value of natrium arsenite was studied in the Laboratory for Insecticide and Fungicide Research by N. C. Wyschelessky. Arsenic acid being able to give salts of different composition, sodium arsenites with various contents of AS_2O_3 and Na_2O were obtained; the AS_2O_3 value of these compounds varied from 42.86 to 85.15%; the latter salt proved, on nearer examination, to be of crystalline structure.

The toxicity of these preparations was tested on black beetles, locust nymphs and mosquito larvae.

For comparison, experiments with white arsenic were also carried out. It was shown that the toxic value of the sodium-arsenite compounds investigated corresponds to their arsenic contents, the greatest toxic power being that of the sodium arsenite containing 85.15% AS_2O_3. On the other hand, there was no difference in the toxic effect, if the various compounds were taken in equivalent doses, i. e. if the AS_2O_3 contents of all doses were the same.

The different quantities of alkali Na_2O given had apparently no noticeable influence on the toxic value of the compounds used. The toxicity of our sodium arsenites exceeded that of white arsenic. The toxicity of sodium arsenite with an 85.15 % contents of arsenic was lowered by the addition of free white arsenic.

The investigation of the toxic action of various sodium arsenite compounds was accompanied by a study of their physico-chemical properties and an experimental control of the factory methods of their production.

We now produce factory-made sodium arsenites with 85.15% of AS_2O_3. This substance is of special interest for us, owing both to its high toxic power and to the simplicity of its production. In accordance with the data of the above mentioned investigations, certain standard conditions have been fixed for sodium arsenites.

Comparison of Toxic Value of Calcium and Sodium Salts of Arsenous and Arsenic Acids.

It was in 1925 that we studied calcium arsenate under field-conditions for the first time. The experiments were made with some American preparations containing from 25 to 40 % AS_2O_5 and some free lime. The action of these preparations was tested on locust nymphs, the dusting method being used; the results were negative, a very low mortality of the insects being observed in the dusted areas. This failure led us to re-examine the problem of toxicity of arsenates and arsenites for our conditions and for our species of injurious insects.

With this purpose we studied the action of various calcium arsenates and arsenites on black beetles and locusts, using both the arsenates imported from America and a series of salts with a high percentage of arsenic, prepared in the Laboratory for Insecticide and Fungicide Research. The following compounds were used:

Nos.	Name of arsenical preparation	% As_2O_3	% As_2O_3	% CaO	relation % $\frac{As_2O_3}{CaO}$	relation % $\frac{As_2O_3}{CaO}$
1.	Calcium arsenate	67.03	—	7.14	9.38	—
2.	Calcium arsenate	46.64	—	31.34	1.46	—
3.	Calcium arsenite	—	30.67	14.46	—	2.12
4.	Calcium arsenite	—	31.79	46.22	—	0.68
5.	Calcium arsenite	—	72 60	23.13	—	3.11

The results of our experiments on black beetles may be seen in the following table:

Percentage of arsenical preparation contained in bait;	5 %	2.5 %	1 %
Nos. of preparations according to previous table	Mortality of insects		
1.	100 %	100 %	00 %
2.	100 %	90 %	45 %
3.	85 %	90 %	—
4.	55 %	60 %	—
5.	100 %	90 %	—

The same results were obtained on locust nymphs. As can be seen from the above tables, the toxic value of calcium arsenates and arsenites grows with the increase of their contents of arsenic oxide, the relation of the contents of arsenic to that of calcium being of special importance: the greater the arsenic value (resp. the lower the calcium value) in a compound, the greater the toxicity of that compound.

Special experiments were set up to determine the influence of the presence of lime on the toxic power of calcium arsenates and arsenites: It was found that the presence of considerable quantities of free lime in these preparations lowers their toxic power, and can therefore act as an antidote. This was shown experimentally on black beetles in the following way: first, the minimum lethal dose of calcium arsenate in the bait was determined; then the same dose was used, but with an addition of lime to the bait, this reducing considerably the mortality of the black beetles. These results were confirmed by a chemical analysis; the quantity of arsenic recovered from the tissues of insects killed with calcium arsenate or arsenite was less than that recovered from the tissues of insects that had remained alive after receiving the same bait, but with an addition of lime.

It may be supposed that the presence of lime lowers the solubility and hydrolysis of calcium arsenates and arsenites, thus diminishing their absorption in the alimentary canal.

Our experiments show definitely that calcium arsenate preparations that are effective in the case of the cotton weevil, are not sufficiently toxic for poisoning locusts. However, by increasing the arsenic contents of these compounds (in our experiments on black beetles and locusts to about 70% arsenic oxide) we have obtained preparations having a powerful toxic action on locusts.

We have also observed that in the case of high arsenic contents there is hardly any difference in the toxicity for insects between arsenates and arsenites. Now, the question as to whether to use, for insecticidal purposes, preparations of tri- or pentavalent arsenic, is of great importance for us, in view of the fact that arsenic is found in Europe and Siberia mostly in the form of realgar and mispickel, minerals that are used for the factory production of AS_2O_3. Consequently, our chief attention should be given to arsenites, instead of following the example of the United States, where arsenates are mostly used as insecticides.

We manufacture at present a calcium arsenite containing 70—72% AS_2O_5; this preparation is most toxic for insects. We have compared the action of this salt with that of sodium arsenite on black beetles and locusts (the latter insect both under laboratory and field conditions). The toxic power of the calcium arsenite exceeded that of the sodium preparation even when the latter had a higher percentage of arsenic (J. A. Parfentjev 1926, 1927). These results were confirmed by experiments on rats and suslik.

GAS DISINFECTION OF GRAIN.

Workers in applied entomology are greatly interested in the problem of replacing carbon bisulphide by other less inflammable gaseous substances. With this aim the Laboratory for Insecticide and Fungicide Research studied the toxic action of a series of volatile compounds on the granary weevil, the acarid *Tyroglyphus farinae* and other insects injurious to grain and flour. Among the various compounds tested, the Laboratory chose, in the first place, chloropicrin, in view of the remarkable insecticide power of this preparation. It was, namely, found that weevils (both larvae and adults) died after being subjected for 24 hours to the action of 0.1 volume% chloropicrin in an empty, hermetically closed, vessel. Another fact in favour of the use of chloropicrin is its safety as a non-inflammable substance.

However, before coming to any definite conclusions as to the advisability of using chloropicrin for grain disinfection, it was necessary to determine whether this substance had any injurious effect upon grain or flour.

Our attention was directed, in the first place, to the influence of chloropicrin on the germination-power of seeds. Our observations in this respect do not accord with those of numerous foreign authors who, repeatedly, refer to chloropicrin-fumigation as a process having absolutely no injurious effect on seed-germination: in our experiments we have noted many cases of diminution of the germination-power of seeds fumigated with chloropicrin. This discrepancy may be due to the fact that in our experiments the seeds were fumigated for 24 hours, i. e., the usual duration of grain fumigation, while many other authors subjected the grain only to 2 or 4 hours fumigation.

We also found that not all seeds are equally sensitive to chloropicrin. Different cereals show great variations in this respect: rye and wheat are more sensitive to chloropicrin than oats and barley. Even the sensibility of one and the same species may vary according to the degree of humidity of the seeds, as can be clearly seen from the following table, where the data of some of our experiments are given:

Humidity of seeds	Germination power	Note
12 %	80 %	wheat seeds, subjected to a 24 hours chloropicrin fumigation; the concentration of chloropicrin was 1. 8 grammes to the cubic meter
15 %	50 %	
16.5 %	30 %	
17.5 %	20 %	

In the above-table, the germination power of control seeds was taken as 100%. An attempt was made to compare the crop-yield of chloropicrin fumigated and non-fumigated seeds. The result of this field experiment is given in the following table:

	Crop-yield of one hectare, in kilograms and in percents		
	oats	barley	wheat
Control seeds	1009.9 100 %	1828.2 100 %	799.9 100 %
Seeds fumigated during 24 hours with 95 ccm chloropicrin to one cubic meter space (i. e. 2 vol. %)	913.4 90 %	1486.3 80 %	244.2 30 %

On the basis of the results of the above experiment, we cannot recommend the use of chloropicrin for fumigating seeds for sowing. A special series of experiments was undertaken to find out how the nutritive properties of grain are affected by chloropicrin.

After fumigating flour with chloropicrin, dividing the flour into portions, and airing each separate portion for a certain period of time, beetle-larvae *(Tenebrio molitor)* were placed in the flour, and their growth was determined from time to time by weighing. The addition in weight of the larvae placed in non-fumigated flour served as control.

Some experiments were also effected on young rats, fed with bread made of chloropicrin-fumigated grain. Rats of the same age, fed with bread made of the same, but non-fumigated, grain, served as control.

Let it be noted that it is difficult to discover, either by taste or by smell, the presence of chloropicrin in bread made of fumigated flour or grain. Nor does the eating of such bread present any danger of poisoning. Nevertheless, continuous feeding of rats with bread made of flour gained by grinding fumigated grain leads to a decreased addition in weight, in comparison with control animals.

In the experiments with the beetle-larvae placed in fumigated flour, the retardation of growth was stronger, possibly owing to the greater surface activity of flour, and its capacity to absorb more chloropicrin than grain. The role of the absorbed chloropicrin was especially noticeable when the larvae were placed in the flour directly after fumigation. The flour was placed in a thin layer on the bottom of open glasses; notwithstanding

this, the larvae died in the course of the first 24 hours. When the larvae were placed in fumigated flour that had been aired for a more or less considerable time, they were not killed, but their growth was arrested.

Consequently, chloropicrin is at present regarded in U.S.S.R. as a most valuable insecticide for the fumigation of empty granaries, stores, and also againt house-hold pests: bugs, cockroaches, blackbeetles (Chloropicrin has been tested for these purposes on a sufficiently large scale). The problem of chloropicrin-fumigation of grain, however, remains unsolved.

The problem of the methods and technique of gas-disinfection is no less important for us.

As yet we have but little applied vacuum apparatus for the disinfection of seeds and other products, although many Entomologists in U.S.S.R. are greatly interested in the problem of gas and vapour disinfection. Among our researches in this direction the following may be mentioned:

N. N. Archangelsky (Station for Plant-Protection in North Caucasus) was able to trace the diffusion of the vapours of carbon bisulphide into the grain to a much greater depth than was supposed before. He found that if a sufficient concentration of carbon bisulphide be released under the grain, the vapour penetrated two meters deep into the grain.

The problem of diffusion and absorption of gases and vapours was more detailedly studied by the Moscow Laboratory for the Research of Insecticides and Fungicides, in particular the influence of various factors on the diffusion-rate of gaseous insecticides. It was found that the diffusion-rate grows with the increase of concentration of the gas. Thus, with a sufficient concentration of chloropicrin, the vapour can penetrate into the grain to a depth of two meters.

Further, the Laboratory has studied the technique of introducing poisonous substances. The distribution of different concentrations of the gas or vapour was found to depend to a certain extent on their specific gravity. It was noted, for instance, that a more even distribution of sulphur dioxide was gained by obtaining this gas by means of the "hot" method, i. e. by burning sulphur in the room that is being disinfected; on the other hand, cold sulphur dioxide (from a gas-cylinder) gives an unequal concentration of the gas in different parts of the room; the concentration is not equalized even after one hour. It is interesting to note that in the hermetically closed, oil painted, empty room used for these experiments the concentration of sulphur dioxide, fell by 40% during one hour.

The following table gives the changes in the concentration of sulphur dioxide in a room empty or stored with various commodities (G. D. Ougrioumoff 1925). The goods were placed on the floor of the room to approximately one tenth of its height. Before taking portions of the gas for analysis, the air in the room was stirred. The temperature of the experiments was from 15° to 20° C.

Taking into account the low rate of penetration of gases and vapours into grain, a series of special experiments were carried out by the laboratory to study the technique of gas-disinfection. A special technique was worked out by the laboratory for disinfecting grain kept in the silos of elevators; the silo was filled with grain 10 meters deep.

Nos.	Contents	Initial concentration	Concentration after 10 minutes	Concentration after 60 minutes
1.	Empty room	1.25 %	0.92 %	0.68 %
2.	room with potatoes	,,	0.90 %	0.63 %
3.	rye	,,	0.88 %	0.48 %
4.	oats	,,	6.85 %	0.44 %
5.	buck-wheat	,,	0.80 %	0.39 %
6.	wheat	,,	0.70 %	0.32 %
7.	rye-flour	,,	0.60 %	0.23 %
8.	hay	,,	0.46 %	0.13 %
9.	head-cabbage	,,	0.30 %	0.06 %

The insecticide used was chloropicrin. Before filling up, chloropicrin was sprayed from a knapsack sprayer down the walls of the upper part of the silo, and left to evaporate till the required concentration of chloropicrin vapours was reached. After this, the silo was filled with grain which, thus, fell through air saturated with the vapours of the insecticide. These experiments gave positive results.

Experiments to force the gas through the layer of grain by pressure were carried out with hydrocyanic acid and carbon dioxide. It is known that hydrocyanic acid gas hardly penetrates into the grain at all; the technique used in the laboratory permitted to blow this gas through layers of grain of considerable depth, up to 1.65 meters.

Control of Acrididae in U. S. S. R.

I. A. Parfentjev, University of Moscow, U. S. S. R.

Great attention is being given in U.S.S.R. to the control of *Acrididae*. This work is under the general supervision of the Bureau for Plant-Protection of the Separate Republics of U. S. S. R. of the People's Commissariat for Agriculture, and at the expense of the State.

It is possible to judge of the scale on which this work is carried on from the size of the territory subjected to *Acrididae* control during the last ten years, as shown by the official data of the Bureaus for Plant-Protection.

Year	Territory in hectares
1919	11,000
1920	29,000
1921	120,000
1922	381,000
1923	1518,000
1924	960,000
1925	547,000
1926	318,000
1927	392,000

Measures against *Acrididae* are being taken in numerous parts of the Union, except North Russia, and are directed against *Locusta migratoria* L., *Deciostaurus marrocanus* Thunb., *Gomphocerus sibiricus* L., *Arcyptera microptera* F. W., *Calliptamus italicus* L. and other species.

The work of *Acrididae* destruction is carried on mostly among wild cereal vegetation and only rarely on cultivated soil. Indeed, with every year the cultivated areas are becoming more and more free of *Acrididae*, and the control is gradually shifted to the breeding places of these pests on non-cultivated ground, thus assuming a preventive character; in this respect, the use of aviation is of great help for the suppression of the migratory locusts on their breeding grounds.

Such breeding places are situated on the swampy shores of the South Russian rivers and lakes, with abundant and partly flooded reed-beds (*Phragmites communis*). The oviposition usually takes place in these swamps on dry ground; and though the eggs are often submerged during the floods, they do not lose their power of development, and nymphs are hatched as soon as the flood-season is over and warm weather has set in.

Laboratory experiments have shown that locust eggs (at least in the first stage of their development) can remain in water without injury during one or two months, and possibly more. The locust nymphs feed in the swamps mostly on reeds, live in swarms both among dry and flooded reed-beds, and can swim easily when compelled to do so.

The use of dry-land methods of insect-suppression is most difficult in these inaccessible swamps; on the other hand, the existence of such sources of locust-invasion is a constant danger for the surrounding agricultural districts. Only the use of aeroplanes has permitted us to undertake an organised control of these locust breeding grounds.

Chemical methods of locust control were undertaken in Russia on a larger scale in 1910—1911; mechanic measures, such as chasing the locusts into trenches, a. o., are now used only in exceptional cases, for inst. through the lack of insecticides in the infested locality.

Of the various chemical methods, we apply poison-baits, spraying and dusting. The poison-bait method is used every year in the largest part of the controlled territory; this method is regarded by us as the most economical, the second place being occupied by spraying, and the last by dusting.

Chemical locust destruction is effected by means of arsenical preparations, chiefly sodium arsenite, and in a lesser degree, by Paris-green; other arsenical compounds are less extensively used.

The work of locust control being carried on among wild vegetation, the corrosive action of sodium arsenite on leaves is of no importance. For spraying crops, calcium arsenite, obtained by adding ex tempore lime-milk to sodium arsenite solutions, is used; sometimes Paris-green spraying is applied. In 1925, locust destruction by means of the dusting method was introduced.

In 1925, one thousand hectares were dusted against locusts by aeroplanes, in 1926 ten thousand, and in 1927 thirty thousand.

A description of the separate methods of *Acrididae* control is given below.

The Bait Method.

This method is widely used by us as a measure against locusts and grass-hoppers. We regard it as the simplest and cheapest, and as giving quite reliable results in the majority of cases. As basis for the baits we use furfur and seed-cake, as well as saw-dust and horse-dung. In some cases so-called green baits are used, i. e., cut grass is sprayed with arsenical preparations. In our practice it is not customary to add sweet or aromatic substances to the bait, or any compounds increasing the humidity of the bait. The experiences of Russian Entomologists show that the cost of such substances exceeds the value of the results gained by their use. For example, P. Berejkoff (1924) found that common salt in small quantities does not influence the humidity, whilst in large quantities it lowers the attraction of the bait for the insects.

At the same time, practice shows that the *Acrididae* usually readily devour baits of the above-mentioned composition. In most cases it is noted that an increase of the humidity of the bait heightens its attraction for *Acrididae*. This is especially noticeable when using baits against locusts in droughty areas. However, the humidity of the bait may be raised only up to a certain point, above which spreading the bait begins to become difficult. In Siberian conditions, on the contrary, it was found (1924) that an excess of humidity in the bait is not necessary, as even dry furfur, saw-dust and dung are readily eaten by *Acrididae*. Sodium arsenite is mostly used in the baits, sometimes it is substituted by Paris-green or white

arsenic. According to our practice, one and a half times, or twice more Paris-green and white arsenic is taken than sodium arsenite. Attempts are being made at present to use calcium arsenite in baits. The problem of bait-composition has been so often raised in international Entomological literature that we feel justified in discussing more closely the various recipes for baits that have gained approval under our conditions of locust control on a large scale. For example, in the Far East of U. S. S. R. the bait for the following species of grasshoppers: *Gomphoceros sibiricus, Arcyptera microptera, Arcyptera fusca, Stauroderes morio, Bryodema tuberculatum, Prumna primnoa,* is prepared in the following way: 400—600 grams of sodium arsenite, dissolved in 12 litres of water, are added to 16—24 kilograms of flour furfur. This quantity is sufficient for spreading over one hectare. When there is no furfur, horse-dung or sawdust it used. Sometimes, instead of sodium arsenite Paris-green is taken, but a double quantity of the latter is necessary (The Far-East Station for Plant Protection, Chabaroffsk 1926). In Siberia, poison-baits for *Gomphoceros sibiricus* and other grasshoppers are prepared as follows: 600—800 grams of sodium arsenite are dissolved in 12 litres of water and added to 20—24 kilograms of furfur; during the last few years, furfur is substituted by 16—20 kilograms of dry horse-dung (N. M. Valoff 1922).

In Azerbeidjan, for nymphs (1st and 2nd stages) of the Maroccan grasshopper, poisoned baits are prepared by taking 600 grams of sodium arsenite or 800 grams Paris-green to 32 kilograms of furfur and 24 litres of water (per hectare). For more adult nymphs the quantity of natrium arsenite is raised to 800 and Paris-green to 1200 grams, the quantity of furfur and water remaining unchanged (Z. S. Rodionoff 1924, Bakou).

The destruction of the migratory locusts by means of poisoned baits is more difficult; it has been noted that the nymphs (1st and 2nd stages) do not readily devour poisoned baits of the usual composition. A great effect can be obtained by using poisoned baits against more adult locust larvae, beginning with the third instar (Z. E. Moritz-Romanoff 1925). However, in swamps the method of poisoned baits, such as has been described above, gives no positive results whatever when used against the migratory locusts. The locust usually does not devour poisoned baits of sawdust, furfur, or dung in reed-beds; in addition to this the reed-beds are often flooded, and it is therefore extremely difficult to scatter the bait.

It is interesting to note that the swarm of locusts will devour the usual baits when it has passed from the reed-beds to neighbouring areas with meadow-grass, or any other flora, or with no vegetation. A worker of the Laboratory for Insecticide and Fungicide Research, G. A. Tchigareff (1927), has, accordingly, effected some successful locust-control experiments in Central Asia.

It was found that calcium arsenite can be successfully substituted for sodium arsenite. Calcium arsenite having a greater toxic value, the same concentration of the poison added to the bait gives a higher percentage of mortality.

It is known that sodium arsenite can be introduced in baits in comparatively small quantities, not more than 2% of the total weight of the bait; a further increase of the quantity of sodium arsenite diminishes the attractiveness of the bait for locusts. The percentage of calcium arsenite, on

the contrary, can be increased to 5% and more, such baits being most avidly devoured by locusts. The use of baits with a high percentage of poison permits to attain more rapidly a more complete destruction of locusts. Further, it was found that in the dry areas of Central Asia the attractiveness of the bait grows in proportion to its contents of water. Using calcium arsenite and furfur, it was possible to produce baits with a good spreading-power containing water up to 100% of the dry substance. Finally, the preparation of the bait by evenly mixing the furfur and the calcium arsenite presents no technical difficulties; and there is no need to heat water, a process which is necessary for more rapidly dissolving the sodium arsenite, and which presents one of the chief difficulties in the work of locust-destruction in scantily populated districts.

In addition to the before-mentioned substances serving as a basis for the preparation of the baits, sometimes fresh-cut grass is used. In the Semipalatinsk district, A. F. Hoffmann (1921) recommends the use of special "Trap-strips" to impede the access of the winged grasshopper to the crops. Fresh grass is cut, scattered in strips of heaps in front of the crop, and sprayed with Paris-green or sodium arsenite. The winged grasshoppers avidly devour this bait.

In swamps, green baits were tried by N. V. Antonoff in combination with mowing: In the high reeds a series of passages were cut at an angle to the direction of the movement of the locusts, the distance from passage to passage being 20 meters; the cut vegetation (reeds and spear-grass) was sprayed with a solution of sodium arsenite (0.8 kilogram to 12 litres of water). The swarms of locust nymphs readily came out into the passages and devoured the prayed cut grass (B. A. Pouchoff 1927).

In the course of the development of the bait-method in our country special apparatus for the mixing and spreading of baits were tried, without, however, coming into general use. Baits for Acrididae destruction are prepared without special machinery: the poison and the base of the bait are mixed in simple vessels (pails, barrels, etc.) with spades, sticks, etc.

The success of the bait-method in U. S. S. R. is due both to the great mortality of the insects achieved by the use of this method, and to its simplicity and cheapness owing to the absence of special apparatus, such as is necessary with spraying and dusting. Our experience shows that with the use of the bait method it is easier to induce the population to take an active part in locust-control measures than if any other method is used.

The Spraying Method.

The spraying method was the first one used in our country, and it is still widely employed throughout U.S.S.R. The following figures will show the present application of this method, in comparison with other measures of locust control. In 1925, of the 590 thousand hectares subjected to anti-*Acrididae* measures, 30 thousand hectares were sprayed. In 1926, the spraying method was applied on 20 thousand hectares, the total area subjected to *Acrididae* control being 318 thousand hectares.

For *Acrididae* control, sodium arsenite is mostly used, and less frequently Paris-green. These insecticides are applied either alone, or in combination with ingredients; among the latter we use chiefly lime, sometimes treacle, and still more rarely zinc oxide.

It should be noted that the spraying of gramineous vegetation, reeds included, presents a series of difficulties; one of these is the low capacity of the leaves of these plants to be moistened with water. Special researches were therefore undertaken to study the spraying method more in detail. This work was carried out in two directions: the study of substances influencing the surface activity of water; and investigations of the contact-action of sprayed insecticides. In our search for surface-active ingredients we had to choose among the cheapest substances. At the same time, in our practice, we were confronted with the fact that the choice of surface-active substances cannot be effected uniformly for all U.S.S.R. Owing, probably, to local peculiarities of water in different parts of the Union, an optimal increase in the adhesion of water to the leaves is gained by applying defferent substances. In Central Asia in particular, we found that the addition of soap to sodium arsenite solutions improves considerably the wetting of reeds and cereals; and a greater mortality of the locusts is achieved than when spraying sodium arsenite alone; the same dose of arsenic gave a 30% greater mortality after the addition of soap. We found, however, that only considerable addition of soap (in our experiments up to 200 grams of soap to 12 litres of water) could increase the humidity of the leaves. Smaller quantities of soap were ineffective. This is obviously due to the fact that water that has to be used for spraying in many areas of Central Asia is saline, and small quantities of soap are easily precipitated. Accordingly, the necessity to add great quantities of soap increases the cost of spraying. Therefore, the use of soap in some Central Asiatic and other districts with saline water cannot be regarded as an advantageous solution of the problem of increasing the adhesiveness of the water to the leaf-surfaces. The Entomologists of U. S. S. R. are at present highly interested in the problem of contact-spraying. Our experiments in this respect were effected in two directions: the study of the contact-action of sodium arsenite, and that of other substances, among them turpentine and mineral oils. The author's laboratory experiments tested the contact action of sodium arsenite solutions. The technique of the experiments was such as to exclude the possibility of the poison getting into the body through the mouth. The dorsal side of the abdomen of black beetles was besmeared with a solution of sodium arsenite. Death of the insects took place under the influence of 2—20% solutions; every beetle received from 0.01 to 0.05 cc. of the solution. The cnntact action of dry sodium arsenite (dusting of the abdomen) was less definite.

We have also observed the contact action of sodium arsenite in field conditions; it was manifest when the nymphs of *Locusta migratoria* were amply sprayed with a 2—3% solution. The quantity of liquid used attained 500—1500 litres to the hectare, and the death of the nymphs took place very soon, usually in a few hours. The work of spraying was generally done late in the evening when the locusts were asleep on the reeds; in the morning, the nymphs were dead, death having taken place during night, i. e., during the period when the nymphs take no food.

These experiments were tried on more adult nymphs (IV. and V. stages). The number of dead nymphs was 500—800 insects to one square meter.

Among other investigated substances, we have observed the contact

action on locusts of turpentine, kerosene, and solar oil. Total destruction of the larvae was attained by using 600—1000 litres of these substances to the hectare.

It must be noted that smaller quantities of arsenical preparations are used, when vegetation that serves as food for the *Acrididae* is sprayed, i. e., when the insecticide is used as a stomach poison; in this case, only about 400 litres of liquid are needed for spraying one hectare, the solution of arsenite used being from 0.3 to 0.6%.

Therefore, the use of insecticides as poisons is much more economical than the so-called contact spraying. However, in the case of herds of *Acrididae* and especially in the case of the migratory locust, the difference in the expenditure of insecticides by the two methods can be diminished. Contact-spraying, namely, should be used only during the time when the locusts assemble in dense swarms for the night. The swarm occupies then a much smaller area than during feeding-time. On the other hand, the extensive areas that have to be sprayed in feeding-time increase considerably the expenditure of insecticides.

But contact-spraying has other advantages: For instance in the case of cold weather, prolonged rains, and during change of integument, all work with stomach-poison has to be stopped, for the feeding of the *Acrididae* decreases considerably. The result of spraying the locust-nymps with contact-poisons does not, however, seem to depend on these factors.

With a view to economise in kerosene, turpentine and solar oil, we attemped to use these substances in water-emulsions, adding various emulsifiers. However, the emulsions had a much weaker effect on the locusts.

Up to now the work of locust-destruction has been carried out only against the non-winged locusts. True, during the first few days of the winged stage it is still possible to destroy this insect by means of the usual methods (baits, spraying, dusting). But as soon as the locusts begin to fly, control is stopped. The introduction of contact-insecticides has made it possible to begin experiments of locust-control during the flying stage. One of the reasons preventing the destruction of the flying locusts is the extreme timidity of these insects. At the approach of man the swarms of locusts fly away. It was observed, however, that during the night, from 11 or 12 p. m. to 4 or 5 a. m., in using acetylene lamps, it is possible to spray these locusts without frightening them off, and we found that the above-mentioned contact-poisons produce their toxic effect on the imago-stage as well.

The Dusting Method.

The dusting of plants with dry insecticides and the use of aeroplanes in insect control were begun in U. S. S. R. simultaneously. The first experiments were effected in the neighbourhood of Moscow in 1924. During the next three years the avio-chemical method was applied to locust control in swamps.

In 1925 an aeroplane-expedition worked in the swamps of the river Couma (North Caucasus); in 1926 in the swamps of the rivers Soulak and Terek (North Caucasus); and in 1927 in the area of the river Syr-Darja (Central Asia). In addition to this, in 1926, an experiment of dusting pine-woods against *Liparis monacha* was undertaken on a small

scale in the Nijni-Novgorod district; this year (1928), similar experiments are being carried on against *Tortrix viridana*. The substances dusted were sodium arsenite, Paris-green and a calcium arsenate containing 25—40% AS_2O_5. The last, however, in view of its low toxic value for locusts, is used no more.

Most work was done with sodium arsenite. We have as yet no fixed standard for the smallness of the particles of sodium arsenite; but positive results were obtained by using sodium arsenite passed through a sieve with 2000—3000 apertures to the square centimeter. Sieves with smaller apertures were not used by us.

So far we have been using for dusting purposes pure insecticides, no other ingredients being added; in the first place, such an addition gave us no special improvements, and on the other hand, we did not wish to overburden the aeroplanes with substances of secondary importance, the more so as it was observed that the added ingredients easily separate in the air from the insecticides. The data of the laboratory for Insecticide and Fungicide Research show that it is most difficult to find a mixture of dusts with an equal falling-rapidity of their particles; and without this, it is difficult to attain an even spread of the dusted mixtures, and to avoid a separation in the air of the insecticide from the additional ingredient.

The expenditure for insecticides was controlled by regulating the quantity of dust discharged per hour.

The experiments for studying the methods and technique of aeroplane-dusting were undertaken collectively, entomologists, chemists, meteorologists, engineers and aerodynamists participating in them.

The dosage of the poison for practical use was settled on the basis of our observations concerning the compactness of the layer of insecticide necessary to produce a lethal effect on the locust. Thus, it was found that a high mortality of locust nymphs (of IVth and Vth instars) was obtained by using 1—1.5 kilograms of sodium arsenite to the hectare of leaf-surface. In the reed-beds dusted by us the leaf surface often exceeded that of the ground occupied by the plants. It is therefore necessary to vary the dosage of insecticides for practical use according to the dimensions of the leaf-surface.

For better adhesivity, dusting is effected early in the morning or late in the evening when there is no wind (or when the strength of the wind does not exceed three meters per second) and in the presence of dew. The aeroplane flies five or ten meters above the plants.

Experience shows that, other conditions being equal, the above mentioned meteorologic factors. dew in particular, influence considerably the quantity of insecticide retained by the leaves. Thus, in two parallel experiments, all other conditions being equal, it was found that 72% of the sodium arsenite dusted in the presence of dew was retained by the plants, and only 20% when the dusting had been effected in the absence of dew. The same difference is found in the mortality of the nymphs, when using the same quantity of insecticide under different meteorologie conditions Owing to the great variety of meteorologic conditions in various parts of the Union it is necessary, when dusting swamps against locust-nymphs, to use different concentrations of insecticides.

In North Caucasus, for instance, in the excessively damp territory situated along the coast of the Caspian Sea, 2 to 4 kilograms of sodium arsenite to the hectare were sufficient for destroying the locust. In Central Asia, where the climate is dry and less favourable for the adhesivity of insecticides, from 4 to 6 kilograms sodium arsenite were necessary.

In order to distribute the insecticide over the territory in a definite concentration, it was necessary to know how far the dust from the machine spreads. For this purpose the Expeditions effected a series of special chemical and biological analyses. The chemical investigation of the area dusted was effected by placing at intervals perpendicular rows of crystallizers along the flying line of the aeroplane and determining chemically the quantity of poison in them after dusting; the leaves around the crystallisers were gathered and their arsenic was also determined. Further, rows of entomological cages, or bag-nets (hanging cages) containing a definite number of nymphs were placed in lines parallel with the rows of crystallisers. These investigations showed that under the conditions of the experiments the area dusted with poison was 200 meters wide.

The distribution of the insecticide was not even: a considerable portion of the dust fell out in a narrow strip in the middle of the line of flight. Observation of the mortality of nymphs showed that the insecticidal action of 4 kilograms of poison per second in the presence of dew was about 100 meters wide. The leaves of reeds within the limits of these 100 meters were covered with a dose of sodium arsenite corresponding to 0.8—1.0 kilograms per hectare of leaf-surface, and the mortality of the locust-nymphs was high; at a greater distance from the line of flight the concentration of arsenic was much lower.

The knowledge of the spread of the insecticide permitted us to determine more accurately the effect of aeroplane-dusting; it was found, for example, that the dusting of one hectare took about three and a half seconds.

As to the general efficiency of aeroplane-dusting, it depends not only on the velocity of the dusting-process itself, but also on many other factors (the carrying capacity of the aeroplane, the velocity of flight, the distance from the aerodrome, etc.). Aeroplane-dusting is accompanied by a number of accessory functions, such as signaling, scouting for locust, etc.

The average area covered is 40 hectares per flight, or 140 hectares per hour. Therefore, in favourable conditions one aeroplane can dust about 500 hectares a day. Not counting the price of the insecticide, the dusting of one hectare costs about 1 to $1^1/_2$ dollars. As to the cost of usual methods of locust-control (without the help of aeroplanes), it varies in different districts of the Union according to local conditions (cost of labour, distance of place of work from railway centres, etc.), the total cost being from one to four dollars per hectare.

Discussion.

Dr. P. Vayssière: A l'occasion de la très intéressante communication de M. Parfentief, je signale au Congrès que l'Afrique du Nord a été, à la fin de l'année 1927, envahie par des vols de Criquets pélerins *(Schistocerca gregaria).* L'Égypte et le Maroc furent les régions les plus

visitées par le fléau. Nous n'avons pas eu de précisions sur les points d'origine des vols qui s'abattirent dans le Sous, mais il est vraisemblable, d'après les renseignements obtenus, que ces points étaient à proximité du versant méridional de l'Anti-Atlas. Les essaims, à leur arrivée dans le Sous, se répandirent dans le pays en se dirigeant vers le nord. Ils furent arrétés par le Grand Atlas, ce qui permit à la population indigène, qui souffrait de la famine depuis près de 8 ans, de trouver dans ces insectes une nourriture abondante, non seulement pour le moment de la récolte, mais aussi pour l'avenir (conserves salées).

Au moment de la ponte, fin décembre 1927 et janvier 1928, il fut remarqué que les femelles, sous l'effet de facteurs indéterminés, ne deposèrent pas, pour la plupart, leur ponte dans le sol; elles laissèrent tomber leurs oeufs pendant le vol ou les abandonnèrent sur le sol. Dans ces conditions, la génération suivante fut extrêmement peu importante.

Grâce à d'obligeants corespondants, j'ai pu obtenir d'abondants échantillons de *Schistocerca,* recoltés soit dès l'arrivée des premiers vols à Tisnit, soit au moment, ou quelques semaines après, les vols tourbillonaient au-dessus de Biougra. D'après l'examen de certains exemplaires communiqués à Uvarov, il parait établi que, dans les premiers vols, il y avait surtout des *Schistocerca gregaria* ayant de nombreux caractères de *flaviventris* (phase solitaire), tandis que dans les suivants ce sont des *Schistocerca gregaria* typiques (phase gregaire) qui dominaient. Ces observations paraissent conformes à la théorie des phases, élaborée par Uvarov, mais il est regrettable qu'elles n'aient pu être aussi complètes, dès l'annonce des premiers vols, que celles effectuées antérieurement par Johnston au Soudan Egyptien.

C'est pourquoi, nous avons cru utile de rappeler l'importance qu'il faut attacher, au point de vue économique, aux observations biologiques. La Commission Nationale D'Études des Calamités de France transmit à Genève au Comité des „Matériaux d'études des Calamités" un voeu qui fut communiqué aussitot à L'Institut Internationale d'Agriculture de Rome. Il est demandé à cet etablissement d'intervenir auprès du centre anti-acridien de l'Afrique du Nord (Alger) pour organiser au plus tôt la mission scientifique destinée a étudier la biologie du Criquet pélerin. M. le Professeur Marchal demanda au Résident de la France au Maroc de mettre la même question à l'ordre du jour de la Conférence nord-africaine qui se tint en juillet dernier et qui adopta le principe de la mission. Il est à souhaiter que maintenant la réalisation de celle-ci sera prochaine.

Researches in Insect Toxicology.

J. A. Parfentjev, Moscow, U.S.S.R.

(With Plate V.)

The growing importance of the chemical method of insect control is conducive to a detailed study of the action of insecticides on the organism of our species of insect pests. And as insect toxicology is a subject that has not been much studied, particular attention had to be given by us in the course of this work to the question of method.

In this respect, we were especially interested in the methods of comparing the toxic power of various insecticides. For effecting the assay of the toxicity of various arsenical preparations, we tested their insecticide action when given in poisoned baits. It was namely attempted to determine the lowest percentage of the various poisons in the bait that is sufficient to kill the insects. By effecting a quantitative analysis of the arsenic contents in the bodies of poisoned insects — both those that had died of poisoning and those that had remained alive — it was possible to estimate more or less accurately the minimum lethal dose of different arsenical preparations. Thus, for instance, our observations on the mortality of black-beetles poisoned with white arsenic showed that the quantity of this poison contained in the bait must be rather high in order to be fatal. The analysis of beetles which had died after devouring this bait gave an average of 0.4226 milligrams As_2O_3 in one insect. Using a more toxic preparation, — sodium arsenite, — death of the insects was obtained with much weaker poison-concentrations in the bait; at the same time, the contents of arsenic in the beetles killed with this bait was less than in the case of white arsenic; for instance, when the bait had been prepared with sodium arsenite containing 42.86% As_2O_3, the average quantity of As_2O_3 in one dead beetle was found to be only 0.245 mg. Beetles poisoned with a still more toxic arsenical compound, with an As_2O_3 value of 85.15%, contained only 0.118 of this poison per beetle. Finally, if calcium arsenate containing 67.03% As_2O_5 was used, the average per one beetle was 0.192 mg. of this salt.

On the other hand, when the baits given contained a higher concentration of the poison, it was impossible to find the minimum lethal dose by determining the arsenic contents of the killed beetles, because the latter might have swallowed an excessive quantity of the arsenic. Another reason for variations in the arsenic contents of dead insects may be the different attractiveness for the insects of baits prepared with a high percentage of various arsenic compounds: for instance, it was observed that beetles do not devour very readily baits with a high percentage of sodium arsenite; therefore, the quantity of arsenic found under such conditions in the poisoned insects cannot give any idea of the lowest dose

of the given compound fatal for the insects investigated; and it is impossible to compare the toxic power of various arsenical compounds on the basis of such determinations.

Below are given the quantities of arsenic found in bodies of nymphs of *Locusta migratoria* killed with baits containing the comparatively large quantities of poison that are used in practical insect control work.

Quantities of arsenical insecticides found in poisoned locust nymphs:

The locusts, poisoned with furfur mixed with various arsenical preparations, were burned with sulphuric acid, after which their arsenic contents were determined colorimetrically. The following quantities of arsenic were found in nymphs of different degrees of development:

% of As preparation in the bait	Insecticide	% contents of the oxydes in the As preparation. % of As_2O_3 in the preparation	Instars of nymphs	Fatal dose for one nymphs in mg.
2%	Sodium arsenite	42 % As_2O_3	III	0.085
,,	,, ,,	85 % ,,	,,	0.016
,,	Calcium arsenate	67 % As_2O_5	,,	0.052
2%	,, arsenite	72 % As_2O_3	,,	0.016
,,	Sodium ,,	41 % ,,	IV	0.051
,,	,, ,,	85 % ,,	,,	0.024
6%	Calcium ,,	72 % ,,	III	0.039
,,	,, arsenate	67 % ,,	,,	0.033
,,	,, ,,	67 % As_2O_5	IV	0.049
,,	Sodium arsenite	42 % As_2O_3	,,	0.032
,,	,, ,,	85 % ,,	,,	0.040
,,	,, ,,	42 % ,,	V	0.079
,,	,, ,,	85 % ,,	,,	0.079
,,	Calcium arsenate	67 % ,,	,,	0.148
,,	Paris green	— —	,,	0.133
,,	,, ,,	— —	,,	0.303

In practical insecticidal work, viz. dusting and spraying, it is important, for an exact determination of the doses of poison to be used, to know the density of the insecticide layer on the surface of the leaves.

In our locust control work by means of the dusting method, we used the following device: a leaf of reed *(Phragmites communis)*, the size of which had been previously determined, was placed in a crystallizer with a definite bottom-surface, and dusted with sodium arsenite by means of a handduster. After this, the sodium arsenite was washed off the crystallizer and its quantity was determined iodino-metrically. Dividing the ascertained quantity of sodium arsenite by the surface of the crystallizer minus the surface of the leaf we found the quantity of poison on one surface-unit of the leaf; several leaves were thus dusted with different quantities of poison. Then the leaves were given to locust nymphs. Observing the mortality of the latter, we were able to judge of the insecticidal power of different quantities of sodium arsenite on the surface of

leaves; and by observing the quantity of leaf substance devoured by the nymph, we could easily determine the dose of poison it had received.

The insects show very soon characteristic symptoms of arsenic poisoning, the first being the appearance of liquid excrements, sometimes in large quantity.

A detailed study of the changes in the inner organs of the locust as a result of arsenic poisoning has been effected by us. Here, the histological changes in the intestinal canal are specially remarkable. The intestinal canal of the migratory locust is a nearly straight tube; the anterior and posterior parts of the canal are long, whilst the mesenteron is comparatively short; however, its dimensions are increased by six finger-shaped diverticuli that open into its anterior end. Each of these diverticuli is nearly of the same size as the mesenteron.

Taken as a whole, the locust intestine is a spacious tube, imperceptibly passing, without any considerable dilatations or strictures along its length, from stomodeum to mesenteron, and from mesenteron to proctodeum; but at about the middle of the proctodeum there is a sharp narrowing of the lumen that corresponds to a sphincter situated in the intestinal wall.

Arsenic poisoning brings about specially strong changes in the mesenteron of the canal; but before describing these changes, a few words should be said about the histology of the normal mesenteron of the locust-intestine.

In the first place, the structure of the diverticuli is different from that of the mesenteron; moreover, there is a certain difference even in the structure of the anterior and posterior diverticular ends.

Let us begin with a description of the diverticuli: there are very deep folds in the epithelial wall of the anterior part of the diverticuli. The external surface of the diverticuli is covered with two layers of muscles: the outer layer is longitudinal, the inner one circular. The epithelium consists of low cells with large nuclei; on preparations fixed by the Fleming method and stained with Heidenhain haematoxiline it is easy to see the chromatine network of the nucleus. The nuclei are round; the chromatine in them is evenly distributed and has the form of a ball of thread, with swellings and larger grains dispersed in it; with stronger magnification it is possible to see that the plasma of the cells has a finely fibrillar structure, which is more distinct in the basal than in the peripheral part of the cells. The majority of these cells is provided with a well-developed "Stäbchensaum". In some places of the diverticle wall there are groups of densely lying small cells, centres of regeneration. In these groups it is easy to find cells in a state of kariokynesis. About the basis of the epithelial cells, a fine membrane of connective tissue, with small cells in it, can be seen; by the Mallory method, this membrane is stained blue. The lumen of the diverticuli is often more or less full of matter.

The posterior end of diverticuli is devoid of the above-mentioned folds. The surface of the wall is very even, without the projections that are characteristic for the anterior end. The epithelium here consists of very small cells; their nuclei are always well stained. The inner surface of the epi-

thelium has a well-developed "Stäbchensaum". The lumen of the posterior end of the diverticuli also often contains some homogenous matter.

The walls of the central part of the mesenteron are nearly even, forming only very small folds that slightly project into the lumen. The epithelium consists of high cylindric cells with slightly elongated nuclei. The nuclei are much smaller than the cells, stained in the same way as the nuclei of the diverticles; the nuclei of this part of the intestine seem to be less rich in chromatine. Groups of smaller cells — centres of regeneration — are situated in the basis of the epithelium. On some preparations, it can be seen that each such group of cells corresponds to one fold. The end of the epithelial cells directed to the lumen has mostly no "Stäbchensaum"; instead, the free end of most cells is provided with swellings of globular form; here and there these globules are round, separated from the cells, and lie free in the lumen. At the same time, the adjacent part of the cells is often full of a transparent matter.

All this points to an intensive secretory activity of this part of the intestinal tract. However, in some cells of this part we also noted the presence of a "Stäbchensaum". In the protoplasm of the basal part of the cells, longitudinal fibrils are to the seen. As in the diverticles, around the basal part of the cells there is a thin membrane of connective tissue, with small cells in it.

The outer surface of this part of the intestine is covered with two layers of muscles: an inner circular layer, and an outer longitudinal one, the latter grouped in separate fascicles. The lumen of the central part of the intestine is full of a rather coarse matter, even little pieces of leaves in the course of being digested: accordingly, we see here a well-developed peritrophic membrane that can defend the delicate walls of the central part of the intestine from the coarse substances eaten.

It is, therefore, possible to admit, judging from the structure of the corresponding cells, that in the diverticuli processes of resorption are prevalent, whilst in the mesenteron there exists a strong secretory activity. This does not, however, exclude the possibility of resorption taking place in the mesenteron as well. We also noticed, though very rarely, the secretion of the above described globules in the wall of the diverticle. In any case, the structure of the diverticles and mesenteron permit to speak of the prevalence in each of its specific function.

After these preliminary remarks, let us describe the changes that take place in the locust-intestine as a result of arsenic-poisoning. The principal changes were found in the mesenteron, especially in its central part. According to N. S. W y s c h e l e s s k y, these changes are the result of necrosis. This is clearly shown in the drawings. The epithelium of the central part of the mesenteron undergoes deep changes: here, the outlines of the cells often disappear altogether, and the wall of the intestine becomes very thin. Here and there, the epithelial cells are desquamated and lie in groups free inside the lumen. In some places of preparations of the central part of the mesenteron no nuclei can be seen. In other places we find nuclei, the chromatine of which is undergoing destruction. Finally, very often, instead of the nucleus, we see uneven grains of chromatine. Such grains very often seem to be surrounded by a vacuole.

In these sections, the nucleus and the protoplasm are stained with difficulty; the protoplasm is in some areas strongly vacuolized.

In some parts of the protoplasm lie rather large uniform grains that can not be stained with nucleal dyes; such grains are often surrounded by a light ring indicating the presence of a vacuole. The surface of the epithelium is uneven and projects into the lumen in the form of small protuberanees of unequal form. The layer of muscle undergoes comparatively less change; but the striated structure that is so distinct in the muscles of the normal intestine is usually not to be seen in the poisoned insects. Consequently, in the poisoned locust, signs of necrosis are profuse in the central part of the mesenteron. In the diverticuli we noticed only local necrotic herds. In the stomo- and proctodeum the necrosis is not so strong. In the proctodeum the principal changes take place in the epithelium of its anterior part. The epithelium of the normal insect consists of low cells with very large nuclei; the chromatine in such nuclei has the shape of an even ball of thread; the protoplasm has a distinct striated structure. In the epithelial cells of the anterior part of the proctodeum of the poisoned insect a destruction of chromatine is to be seen; in many nuclei the chromatine is distributed unevenly. The nuclei of many cells are vacuolized and contain areas were the chromatine is more concentrated.

We see, therefore, that the nuclei of many cells are deformed and the chromatine in them is unevenly distributed. In some cells the outlines of the nuclei have totally disappeared, and instead we find only masses of chromatine.

The changes in the tubuli Malpighii are mostly evident in the sections where these tubes lie close to the necrotised part of the intestine. The changes of the tubes themselves are also of a necroite character. In some sections of the tubes their nuclei remained unstained. In other cells we found destruction of nucleal chromatine deformation of nuclei, chromatolysis, uneven distribution of chromatine in the nuclei, or the formation of chromatine-grains in place of the nucleus. In some preparations a desquamation of the cells inside the tubes was manifest; the lumen of such tubes usually was obliterated.

The crystallic formations in the plasma of the cells, that are so characteristic for the stomodeum and proctodeum, as well as for the tubuli Malpighii of the normal locust, can usually be found in the poisoned locust as well.

Similar changes have been found by us in the intestine of the mosquito larva *(Aedes)* poisoned with arsenic. The mesenteron of these larvae is also necrotised, with a granular destruction of protoplasm, chromatolysis of the nuclei, etc. However, we did not notice in the intestine of poisoned mosquito larvae such deep necrotic changes as in the locust.

In the Laboratory for Fungicide and Insecticide Research, Professor D. W. Nenjukoff is engaged to study in detail the influence of arsenical preparations on the digestive processes of the locust.

As to the action of liquid contact insecticides, we were able to observe that some of them enter the organism by way of the stigmata and the tracheae. In particular, after spraying black beetles and aphids with

turpentine and soap-solutions, we could discover these substances deep in the smallest branches of the tracheal system.

Sensibility of Insects to Vapours and Gases.

The sensibility of various species of insects to insecticides, including gases and vapours, varies considerably. We have been unable as yet to trace any correlation between sensibility of insects to poisons and their species-particularities. It is interesting, for example, that two closely related species of weevils (*Calandra granaria* and *Calandra oryzae* L.) show a great difference in their sensibility to gases and vapours. We studied on these weevils the action of carbon bisulphide, chloropicrin, hydrocyanic acid, sulphurous anhydrid, pyridine, etc. In all cases of fumigation, *C. oryzae* was killed much sooner than *C. granaria*. The difference in sensibility between these two weevils was greater than that between other insects belonging to different families or even orders.

The following table gives the lethal concentrations of chloropicrin for various insects and for the *Tyroglyphus farinae*, in room temperature and with a 24 hours fumigation.

Concentration of chloropicrin vapour:

Name of pest	0.01 %	0.02 %	0.03 %	0.05 %	0.07 %	0.1 %
Calandra oryzae L. (beetle)	dead	dead	dead	dead	dead	—
Calandra granaria L. (beetle)	alive	alive	alive	dead	dead	—
Calandra granaria L. (larva)	alive	alive	alive	alive	dead	—
Sitodrepa panicea L. (beetle)	alive	alive	alive	dead	dead	—
Sitodrepa panicea L. (larva)	alive	alive	alive	alive	dead	—
Tribolium confusum Duv. (beetle)	alive	alive	alive	alive	alive	dead
Tribolium confusum Duv. (larva)	alive	alive	alive	alive	alive	dead
Tenebrio molitor L. (beetle)	alive	alive	dead	alive	alive	dead
Tenebrio molitor L. (larva)	alive	alive	alive	alive	dead	dead
Tenebrio molitor L. (pupa)	alive	alive	alive	alive	alive	dead
Ephestia kuehniella L. (caterpillar)	alive	alive	dead	dead	dead	dead
Tyroglyphus farinae (mite)	alive	alive	alive	dead	dead	dead
Tyroglyphus farinae (larva)	alive	alive	alive	dead	dead	dead
Tyroglyphus farinae (egg)	alive	alive	alive	alive	alive	dead

The cockroach *(Blatella germanica* L.) was more enduring to a larger number of poisonous gases and vapours than the black beetle *(Blatta orientalis* L.). The sensibility of two caterpillars (similar to each other), of the Mediterranean Flour Moth *(Ephestia kuehniella* L.) and the Bird-cherrytree Moth *(Hyponomeuta evonymellus* Sc.) to the action of poisonous gases and vapours, as well as nicotine- and soap-solutions, is extremely different. With any of these poisons, the caterpillars of *Hyponomeuta* perished easier than those of the Flour Moth. Many more examples might be given to the same effect.

In some cases, the two sexes of one and the same species were not equally sensitive to gases and vapours. Thus, the males of black beetles perish easier than the females. We found that the sensibility of the species investigated to gas and vapour poisons depends on their capacity to lose water. This fact was observed by placing the insects in vacuum-exsicators for 30 to 40 minutes under slight heat (from 36 to 40° C), and rarefying and passing the air through calcium chlorate. It was found with this method that, all other conditions being equal, *Calandra oryzae* L. loses in the exsiccator two or three times more water than *Calandra granaria* L. More or less similar results were obtained with black beetles and cockroaches.

Caterpillars of *Hyponomeuta evonymellus* lost in the vacuum exsiccator 7.5—8.2% of their total weight, whilst caterpillars of the Flour Moth lost only 3.3—4.4%. Larvae of *Melolontha melolontha* L., being less sensitive to the action of gas and vapour poisons than their imago, lost in the vacuum 2.6—3.6%, while the adult beetles lost 3.3—5%. In accordance with their greater sensibility to gas-poisons, the male black-beetles lose 10—11%, the females only 6%.

Of the various insects studied the most enduring were *Calandra granaria* (beetles and larvae) and the larvae of *Tenebrio molitor;* and, in comparison with other species of insects, they lost much less water in the vacuum. However, our observations are as yet insufficient to assert the existence of a correlation between the sensibility of all species of insects to insecticides and the degree of losing water.

Our observations permitted us to establish the differences in the loss of water by various species in the vacuum only when the insects remained alive in the course of the experiment. The air in the exsiccator was highly rarefied (6—9 cm Hg.). The temperature and duration of sojourn in the exsiccator had to be slightly varied (from 30° to 40° C and from 30 to 40 minutes), not all insects being able to stand heating in vacuum. The quantities of lost water were compared only for insects observed under absolutely equal conditions.

It must also be remarked that dead insects lost under the same conditions much more water in the vacuum than live ones. This fact can, probably, serve to distinguish live and dead weevils. This problem is raised, because, after fumigation with some gaseous insecticides, some insects, especially beetles, remain in a peculiar state of torpor, and it is very difficult to distinguish them from dead ones. After a considerable time, however, they return to life. Thus, in 1925, we observed that *Calandra granaria* L., being fumigated with insufficient doses of hydro-

cyanic acid gas, fell into a state of torpor lasting up to two weeks. The phenomenon is illustrated in the following table:

% of hydrocyanic acid gas	Duration of fumigation	% of weevils revived in the subsequent days.
3 %	2 hours	2 nd day . . . 0 % 5 th „ . . . 0 % 7 th „ . . . 20 % 13 th „ . . 100 %
0.25 %	12 hours	3 rd day . . . . 0 % 12 th „ . . . . 90 %
0.1 %	24 hours	3 rd day . . . . 0 % 5 th „ . . . . 0 % 6 th „ . . . . 20 %

In all these experiments, individual variations of the sensibility of insects to poisonous substances had also to be taken into account. Therefore, in order to receive average figures, we repeated every experiment several times, using in each test the largest number of insects possible.

The following table shows the individual variations of the sensibility of *Caladra granaria* L. to chloropicrin vapour. The fumigation lasted 3 hours.

0.1 % chloropicrin	40 % dead weevils
0.2 % „	60 % „ „
0.3 % „	80 % „ „
0.5 % „	90 % „ „
0.7 % „	100 % „ „

It was also found in the course of our research that even age-differences can influence the sensibility of the insects to gas and vapour insecticides. Thus, adult beetles of *Calandra granaria* L. have proved to be more sensitive to chloropicrin and carbon bisulphide vapour than those just emerged from the pupae and still having light-brown elytra.

Explanation of Plate V.

Fig. 1. Section across mesenteron of normal mosquito larva *(Aedes)*; fixed with methyl alcohol, stained with Hiemsa; 1500 ×.

Fig. 2. Section across mesenteron of mosquito-larva poisoned with sodium arsenite *(Aedes)*; fixed and stained as in fig. 1; 1500 ×.

Fig. 3. Intestine of normal *Locusta migratoria*; magnified.

Fig. 4. Section across central part of mesenteron of the normal *Locusta migratoria*; 850 ×; a = muscles, b = regeneration-cells, c = epithelium.

Fig. 5. Section across central part of mesenteron of *Locusta migratoria* poisoned with sodium arsenite; 400 ×; Carnoy fixation and stained with Ehrlich haematoxyline and eosine, as in figs. 6 to 10.

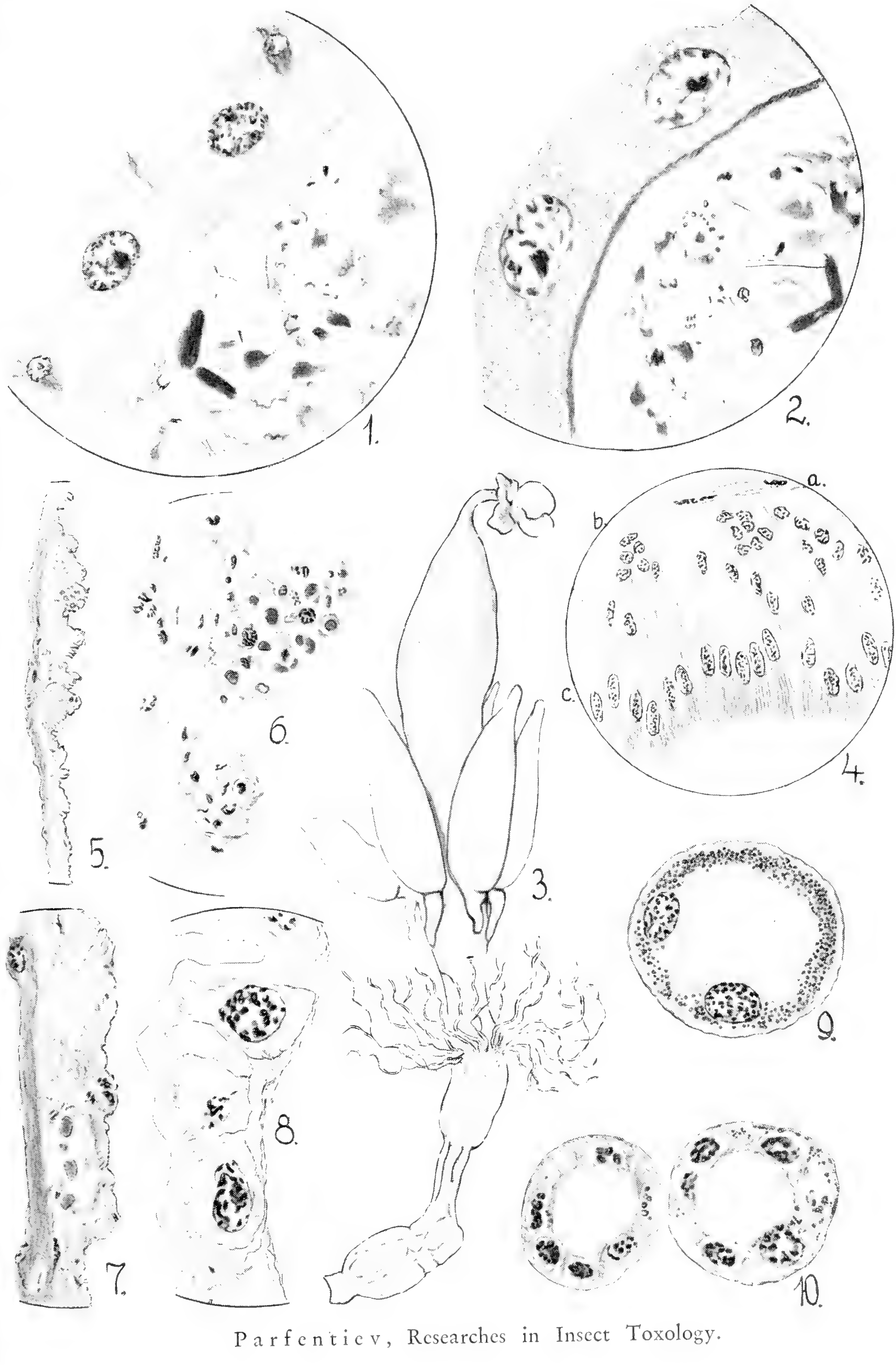
Fig. 6. A part of the same preparation as fig. 5; 1000 ×.

Fig. 7. A part of the same preparation as fig. 5; 700 ×.

Fig. 8. Epithelium of anterior (broad) part of the proctodeum.

Fig. 9. A Malpighian vessel of the normal locust; 1500 ×.

Fig. 10. Tubuli Malpighii of a locust poisoned with sodium arsenite; 1500 ×.



Parfentiev, Researches in Insect Toxology.

Preliminary Observations on the Pine Tip Moth (Rhyacionia frustrana Comst.) on Southern Pines.

Philip C. Wakeley, Assistant Silviculturist,
Southern Forest Experiment Station, New Orleans.

The pine tip moth, *Rhyacionia frustrana* Comst., was first brought to the attention of the Southern Forest Experiment Station by the forester of a lumber company at Bogalusa, Washington Parish, in South-eastern Louisiana. He had begun in 1919—1920 to reforest cut-over lands with loblolly pine, *Pinus taeda,* because of the desirable silvicultural and technical characteristics of that species. In 1921 he began to notice tip moth damage on young, self-sown *P. taeda* in the vicinity; two or three years later he made a vain effort to control the pest in his plantations by collecting and burning the infested twigs. By 1925 his planted and seeded areas included several square miles of young *P. taeda,* all of which was so badly stunted and deformed by tip moth that his company decided to abandon the use of this species for reforestation.

In October, 1924, the Experiment Station first recorded tip moth damage in its own plantations, at Bogalusa. Since 1924, and including the spring field work of 1928, individual records of tip moth damage have been kept for from one to three years on 17,400 planted trees at Bogalusa. These plantation records of damage have been supplemented by caging-experiments to determine more precisely the life history of the insect, and by general observations throughout the southern pine region, by members of the Station staff and others, to learn the range and seriousness of the pest.

I. Taxonomy and Description of the Insect.

On the basis of material collected at Bogalusa, La., Mr. Carl Heinrich, of the Bureau of Entomology, has identified the tip moth for us as a tortricid, *Rhyacionia frustrana* Comst. Adult approximately 6 millimeters long, silvery-gray, with rusty markings, matching perfectly the sheath at the base of the pine needle fascicle, on which the adult frequently conceals itself.

The larvae are small, whitish or pale brown caterpillars, with nearly black heads; the pupae are light brown, and at ordinary temperatures quite active. Larvae and pupae in varying numbers occur in burrows of varying length in the twigs of the food plant, in buds hollowed out from within, and in tunnels or cells in exuded gum on the surface of the injured tip.

The casual observer never sees the insect at all, but soon learns to recognize the characteristic evidences of its work — contorted, gummy, and dying tips on the twigs, made conspicuous for a while by dead needles and finally resulting in disintegrating spikes, which are sometimes capped by aborted buds, often obscured by witches brooms of new growth, and always marked by old emergence holes and clots of white gum.

II. Food Plants, Range, and Principal Occurrence.

The Station has discovered the tip moth on loblolly pine, *P. taeda* L.; shortleaf pine, *P. echinata* Mill; slash pine, *P. caribaea* More; sand pine, *P. clausa* (Engelm.) Sarg.; spruce pine, *P. glabra* Walt.; and Sonderegger pine, *P. sondereggeri* Chapman, which is a hybrid, *P. palustris* x *P. taeda.* Pond pine, *P. rigida serotina* (Michx.) Loud., has not been examined for the pest. Seedlings of western yellow pine, *P. ponderosa* Laws., and transplants of Monterey pine, *P. radiata* Don, have likewise been infested at Bogalusa. Longleaf pine, *P. palustris* Mill., has been scrutinized carefully for several years, but the work of *Rhyacionia frustrana* has never been positively identified upon it by the writer, and work even resembling that of *R. frustrana* is not common.

The moths fly most abundantly and vigorously on warm, bright days, usually remaining, while in flight, within 2 meters or less of the ground. They run with extreme rapidity on the foliage and stems of the pines on which they light, often climbing to heights considerably above 2 meters.

Damage characteristic of the tip moth has been observed on southern pines at a number of widely separated points, from Cherokee Co., Texas, and Ashley Co., Arkansas, east to Georgia and South Carolina. The insects attack everything from six months-old seedlings barely 15 centimeters high to open-grown trees 6.0—7.5 meters high. The worst damage, however, occurs on trees 0.5—2.5 meters high.

The worst damage observed by the writer has been at Bogalusa, La., in extensive pure plantations of *Pinus taeda*, 3 to 5 years old, 0.5—2.5 meters high, containing about 2,200 trees per hectare (nearly 900 trees per acre), with no overhead shade and relatively little intermingled brush, and located on sites apparently not best suited to this species. Some of these unfavorable sites are dry, sandy-loam hills particularly adapted to *Pinus palustris;* others are soggy, ill-drained "craw-fish flats", better adapted to *Pinus caribaea* and sometimes too wet even for that moisture-loving species. Pure, self-sown stands of both *Pinus taeda* and *P. echinata* have occasionally been found almost as heavily infested as these pure plantations on unfavorable sites. On the other hand, pure plantations on favorable sites, although heavily infested, have shown good recovery and have soon passed the stage of greatest injury.

III. Tip Moth Damage in Plantations.

At Bogalusa, La., in the extensive pure pine plantations of various species, the buds begin to elongate in late February and early March, and during March and April normal growth is extremely rapid. In February and March, however, there is a heavy flight of adult moths, which transform from pupae which have overwintered in larval burrows in the pine twigs. In March the new growth on both leaders and lateral branches of *P. taeda, P. echinata, P. caribaea,* and *P. sondereggeri* begins to show infestation, the chief evidence being gumminess and distortion of the growing tips. By the middle of April, young plantations of *P. taeda* show 90—100% infestation of the new growth, *P. echinata* nearly as much, *P. sondereggeri* little if any less than *P. echinata,* and *P. caribaea* a varying amount usually much lower than the others. The growing tips of *P. taeda* are killed back

severely during late April or early May, as are those of *P. echinata* and *P. sondereggeri* in usually less degree. *P. caribaea* is killed back so little, and recovers so well, that evidence of infestation is sometimes difficult to find later.

The tip moth larvae almost never kill trees outright. All four species of pine develop new buds from the highest portion of the growing tissue surviving below the infested leader, and these give rise to new stems which in turn are infested throughout the spring and summer. Life history studies to date indicate three additional flights after that of February and March, with three new infestations after that of March and April.

At the end of the growing season *P. taeda* and *P. echinata* often exhibit a total of 15—30 centimeters or even more of wood killed back within the year on the successive leaders of trees not more than 2 meters high. In addition, the stems are deformed and the crowns often develop abundant witches brooms. *P. sondereggeri* is similarly affected. The total length of leader actually killed is probably too conservative a measure of the loss in height growth caused by the insect.

Pinus caribaea contrasts strikingly with the other species not only in the amount of tip moth infestation, but also in its reaction to the damage. Practically no deformation of the stem results, witches brooms are almost never formed, and dead tissue is difficult to find at the end of the season even on trees noted as infested during the spring and summer. Often the only evidence of damage is a dead bud or growing tip, 2 or 3 centimeters long, forced out at right angles to the leader or to the lateral branch. These buds sometimes contain pupae, but it seems to the writer, from all the available facts, that many of the larvae attacking *P. caribaea* must be killed by the abundant excretion of resin characteristic of this species. An occasional *P. caribaea* accidentally planted among *P. taeda*, can, because of its conspicuous freedom from tip moth damage, be identified readily by an observer in a passing car.

Investigation of a self-sown stand of *P. taeda* on an excellent site near the Bogalusa plantations of the same species showed that most of the trees 1.0—2.5 meters (3.3—8.2 feet) high had been infested with tip moth, but that the damage to any one tree was less than in the plantations and furthermore that the trees had recovered better, with less deformation of the stem and with less tendency to form witch brooms. The self-sown stand occupied a well-drained, well-watered site on fertile soil above a small stream; partial shade was cast by a few decadent oak and gum trees; and the spacing, while irregular, was 1 by 1 meter, or closer, as contrasted with 1.8 by 2.4 meters (6 by 8 feet) in the plantations.

IV. Discussion of Data.

From the observations described above it appears that in the South, *Rhyacionia frustrana* does its greatest damage on *P. taeda, P. echinata,* and *P. sondereggeri,* and that at Bogalusa, La., it produces four broods a year arising from the flights of February-March, May, July, and August-September. The life history, however, needs further substantiation by caging.

The possibility of overlapping broods has been suggested, particularly by Dr. Ivar Trägårdh, of the Swedish Forest Experiment Station.

The rapidity of life processes in the South, however, combined with the fairly sharply defined flights of the adult moths, the reaction of the food plants, the location of the burrows in new growth, and the fairly uniform state of development of larvae or pupae on any given date, all seem to indicate successive rather than overlapping generations. Dr. Trägårdh believed that the immature larvae might exist for a long time as leaf miners. The writer, however, recalls individuals of *P. taeda* completely defoliated by the gray-blight or needle-cast fungus *(Lophodermium australe?)* before the appearance of new growth in March, the new growth, nevertheless, becoming badly infested by tip moth larvae when it did appear. This at least seems to preclude the infestation of new growth by larvae overwintering in the needles.

The ultimate seriousness of the damage caused by *R. frustrana* is hard to predict. It seldom kills trees outright. From its widespread occurrence it would seem to be no new pest, yet second-growth stands of its favorite food plants, *P. taeda* and *P. echinata,* show no serious after-effects of its presence. Without detailed stem analyses of trees above seedling size, or access to past entomological records, it has been impossible for the writer to trace the history of the insect in the southern pine region. Then, too, past history may give no indication of what will happen under the silvicultural practice now being developed in the South. The writer's present feeling is that no permanent, serious deformation of the stems will result under ordinary conditions and that at worst the insect will prolong the rotation of *P. taeda* and *P. echinata* perhaps four or five years. Certainly plantations of *P. taeda* at Bogalusa, on fair sites, are nearly as tall as adjacent plantations of *P. caribaea* and, though only five years in the field and six from seed, contain many trees of good form and of heights up to 2.5—3.0 meters (8.2—9.8 feet). Trees of this size suffer much less damage than those of lower height classes.

V. Possibilities of Control.

Clipping and burning infested tips to control the tip moth is entirely impracticable commercially, even if it should prove effective biologically. The larvae are out of reach of any spray, except possibly for a very brief period in the juvenile stage. Control by means of parasites has not been demonstrated in the South.

The solution of the tip moth problem apparently lies in forest management or in tree breeding. The use of resistant species like *P. caribaea* or *P. palustris,* where otherwise practicable, is completely effective. Damage to *P. taeda* and *P. echinata* may perhaps be reduced by confining these species to favorable sites, mixing them with resistant species, starting them among brush *(Quercus marilandica,* for example), starting them under an overwood, or using a close spacing.

In the Bogalusa plantations certain individuals of *P. taeda* are noticeably more resistant to tip moth attack than the bulk of the trees planted, and are conspicuously better in their recovery from injury. Such trees are being marked for possible breeding experiments, in hopes of developing a tip-moth-resistant strain for future planting.

Insect Inhabitants of the Upper Air.

E. P. Felt, Chief Entomologist, Bartlett Tree Research Laboratories, Stamford, Conn.

Insects took to the air way back in the upper Carboniferous period, and it is not surprising that man, a most recent traveler upon the "wings of the wind" should find much that is new, especially in relation to the insect inhabitants of the air. It is somewhat startling to think of hosts of insects drifting hundreds of miles thousands of feet above the surface of the earth. This does not seem so very unusual when the facts are studied.

We have given, in the recently issued New York State Museum Bulletin 274, 1928, a summary of many insect occurrences heretofore explained by various, and in our estimation, improbable theories, together with an interpretation of these conditions in the light of recently acquired facts in relation to air currents. Numerous records of insects, some small, taken at sea, in deserts, on high mountain tops and even in the Arctic regions, are believed to indicate in large measure casual drift rather than uncontrolled distribution by violent winds or more or less purposive flight. There is no question but that occasional violent storms are responsible for the carrying of birds and insects, for that matter, long distances from their normal range. It is our belief, however, that altogether too much importance has been attached to such agencies and too little weight given to the effect of convectional currents and normal winds upon insect movement. The convectional currents serve as natural elevators, as it were, and undoubtedly carry hosts of insects into the upper air, to altitudes of 3,000 feet or even more, and from such elevations one may reasonably expect extended horizontal drift, since wind velocities of 100 to 200 miles per hour are not uncommon at such heights. The author's work, when connected with the New York State Conservation Commission, resulted in several records of toy balloons drifting 65 to 100 miles per hour, and in one instance there was a drift of 775 miles in a northeasterly direction. These are cited simply to show possibilities, since, once the insects are at a considerable elevation in the air, easily accomplished by convectional currents, a very considerable drifting would be expected.

It may be held that, while the above is possible, there is little evidence to indicate that insects ordinarily allow themselves to be carried to any great height in the air. It is well known that grasshoppers, particularly in the western United States and during earlier years, drifted or flew in large numbers at some elevation, and in at least one instance they were observed at a height in the air of 2,000 feet. There is a record of mosquitoes being taken at 3,000 feet and of honey-bees flying around balloons 900 meters above the surface of the earth. During the summer of 1926 three small flies, a Mesogramma, a Hylemyia cilicrura and a Chrysotus were taken

in a trap attached to an airplane operated from Mitchell Field, Long Island and flown at a definite height, the first two at an elevation of 3,000 feet and the last at an elevation of 1,000 feet. Later an insect trap on a plane operated by Dr. B. A. Coad, an agent of the Bureau of Entomology, Department of Agriculture, made large additions in a line of investigation suggested by our earlier work. These will doubtless become available later. There is also a record of a wasp impinging upon the windshield of a European air liner at 6,000 feet, and of the occurrence of numerous small insects at 4,000 feet. Prof. F. V. Theobald has called our attention to the occurrence of a number of aphids at elevations between 1,000 and 1,600 feet. The earlier records of this character presumably have been regarded as exceptional and as possessing little significance. It appears at least reasonably possible that these records represent a somewhat general movement, though not necessarily a constant one and with this in mind, it is easy to believe that there may be a more or less constant insect population of the air. The numbers of specimens and the height attained must necessarily vary to a very considerable extenx in different seasons, in various sections and be greatly modified by climatic conditions.

The casual attitude of the insect toward distribution by moderate air currents is indicated by the observations of Prof. F. Wood-Jones who states that in periods of absolute calm of long duration a dragon fly, *Pantala flavescens*, was seen by him hawking above the sea 20 miles or more from the nearest land. Furthermore, he observed numbers of this species almost daily in a dead calm all the way from Singapore to Thursday Island. He adds that strong flying butterflies did the same, flying away from the land in an irresponsible way, and that moths came nightly to a ship's light when she was lying 20 miles from shore. Similar records, though perhaps not so clear cut as to the type of flight, are by no means wanting.

The finding of mosquitoes, a water bug *(Corixa)*, small moths, house flies, and even May flies, many miles in the desert by C. B. Williams, late Chief Entomologist of Egypt, is at least very suggestive of the same type of movement as that described by Prof. Wood-Jones. It is well known that insects may be taken in large numbers upon mountains and upon glaciers, and here a casual drifting followed by driving down of the insects by low temperatures or storms appears to be a very reasonable explanation. The occurrence of large numbers of *Dilachnus piceae* and *Syrphus ribesii* on snowy North-East Land, north latitude 80°, recorded by Elton, must be due to such causes. The same, in our opinion, applies to the occasionally abundant and varied insect drift not infrequently found upon the shores of our larger lakes and also along the sea-coasts. The world wide or nearly world wide distribution of certain gall midges, insects with admittedly weak powers of flight, is very suggestive of the part played by air currents. This is also true of a number of other small insects. All of these indicate the probability of a very considerable aerial insect population.

The varied character of the lower aerial insect population is indicated by the writer's collection in 1927 on the roofs of high buildings, especially that of the State Education Building at Albany, N. Y. This structure is located near the center of a city of some 100,000 inhabitants, the roof has a height of 128 to 148 feet above the street level, is considerably higher than

the tops of adjacent trees and at the time the collections were made stood well above most other buildings. Approximately 1,000 different species of insects representing a wide variety of groups were captured. The semi-domesticated honey-bee, *Apis mellifera,* was taken in small numbers from early in the spring to late in the fall, there was a considerable series of ants, probably mostly local, six species of gall wasps, although the nearest oaks were approximately a mile sway, and an abundance of the recently introduced and widely distributed birch sawfly, *Fenusa pumila.* The beetles were represented by a very large series, some 40 families and well toward 400 species. The *Carabidae* were represented by 59 species, the *Chrysomelidae* by 48 species; the *Curculionidae* by 33 species, the *Cerambycidae* by 43 species, the *Elateridae* by 28 species, and the *Scarabaeidae* by 27 species. The somewhat common and at times abundant occurrence of the Colorado potato-beetle, *Leptinotarsa decemlineata,* was unexpected and indicates rather habitual flight at some elevation for a heavy insect. The plantain leaf miner, *Dibolia borealis,* another feeder upon low plants, was rather numerous, and this was also true of the clover leaf weevils, *Hypera punctata* and *Phytonomus meles.* The pales weevil, *Hylobius pales,* was found in small numbers and must have flown at least a mile, since there were no nearby pines. Other pine insects were captured. A series of bill bugs, *Calendra zeae,* was taken, although a specialist advised us that he had no previous evidence of the insect flying. The recently introduced apple and thorn skeletonizer, *Hemerophila pariana,* was rather common on the roof. Numerous specimens of presumably the spruce gall aphid, *Chermes abietis,* were taken and these must have drifted a mile or more. The last two records indicate widespread and general drifting as the most probable explanation of the rapid dissemination of these species in America.

Another record of exceptional interest was the finding of specimens of the recently introduced Japanese Scarabaeid, *Aserica castanea,* a somewhat heavy insect, in July 1927 on the roof of a thirteen-story building at Mt. Vernon, N. Y., and also on the roof of a thirty-story building in the heart of New York City.

The above records give an idea of the abundance and variety of insect life occurring at a considerable height in the air and under what we have hitherto presumed to be abnormal conditions. Are these conditions so abnormal as have hitherto been supposed?

The insects found on islands, some at least very small and remote from large land areas, are also suggestive of general insect drift, since the land areas are so inconspicuous as compared with the wide ocean expanses. The establishment of only a few individuals must mean an untimely end for enormous numbers venturing upon such hazardous voyages. Man's trans-oceanic flights are suggestive along these lines. The re-establishment of numerous insects upon the island of Krakatoa following the terrible eruption of August 1883 is also presumable evidence of general drifting and many of the conditions now obtaining in that section of the world can hardly be explained satisfactorily in any other way.

If a somewhat considerable insect population of the air is accepted, it follows that under certain conditions, such as sudden dropping of temperature, heavy rains or violent winds, there must be a dropping toward the earth of many insects, since they normally seek shelter from adverse con-

ditions. The presumption is that their direction of movement would not be greatly changed in the descent to earth in search of safety, and in any event the sudden and considerable accumulation near the surface would result in a somewhat general movement in certain directions, and this movement might be, and presumably has been, interpreted as purposive migration.

The mass movements of schools of fish, herds of animals and flocks of birds all illustrate the tendency to move along the lines of least resistance or least interference, and to a certain extent these are determined by mechanical factors rather than instinctive or purposive reactions. "Follow the leader" is a somewhat blind though a rather compelling motive.

There are striking movements of insects, but it seems to the writer that in many cases they are casual so far as the insect is concerned rather than purposive. The remarkable appearences of the dragon fly, *Aeschna bonariensis,* before the Patagonian "pampero" recorded by W. W. Hudson comes in this category, in the author's opinion, and the same appears to be true of the occurrence of millions of another dragon fly, *Libellula quadrimaculata,* in Heligoland as recorded by Gätke. Both of these appear to be due to the insects being driven from the upper air by storm conditions and the inevitable concentration at the surface of the earth.

It is the writer's opinion that purposive migration of insects, at least in the broader sense, has not been established beyond question, and furthermore it is his belief that it has been too generally used as an explanation for insect movements.

Polyembryony in Insects.

R. W. Leiby, State Entomologist, Raleigh, North Carolina.
(With Plates VI to XII.)

By polyembryony is meant the development of more than one individual from a single egg. The phenomenon was first described in insects by Paul Marchal in 1904. It is known to occur only in the hymenopterous families of *Encyrtidae, Platygastridae* and possibly the *Dryinidae.*

The polyembryonic species are all parasitic upon other insects. They oviposit in the eggs of their hosts and emerge as adults nearly always from the fully grown host larva. From one to eight eggs are deposited by the female parasite at a time within the host egg. Some species rarely deposit more than one egg in a host egg, while others deposit two eggs as a rule, and still other species deposit from four to eight eggs.

Both fertilized and unfertilized eggs develop, the former giving rise to females and the latter to males. At times one fertilized female may deposit both fertilized and unfertilized eggs in a host egg at one insertion of the ovipositor, and the brood developed therefrom will consist of both male and female individuals.

Whether the egg is fertilized or not, maturation takes place in which the polar bodies are not thrown off. Instead they are retained to form, together with a differentiated part of the egg, a thickened membrane known as the trophamnion which invests the embryonic portion of the egg during early development and later functions as an envelope capable of extracting from the host such elements as are necessary to bring about the development of the parasites from the fertilized or unfertilized egg nucleus to the primary larval stage. Henceforth the growth of the parasites is by direct feeding of the larval stages within the host larva which has meantime hatched from the egg and is growing to reach the pupal stage.

The posterior region of the parasite egg containing the fertilized or unfertilized nucleus becomes enlarged by the division and subdivision of the oocyte nucleus. If it is limited to a single division, only two embryos are formed. In most of the species thus far studied division and subdivision of the embryonic and daughter embryonic nuclei continue to a point where from 16 to 1500 daughter nuclei are formed, which result in the development of as many embryos.

Embryonic development having been completed to the primary larval stage, by means of host elements fed through the trophamnion, the larvae feed directly upon the internal tissues of the host. Their feeding upon the host larva kills it just as it is about to transform to the pupal stage. The parasite larvae have meantime matured. They then transform

to pupae within the carcass of the host larva, and later emerge simultaneously as adults from their individual cells in which they have passed the pupal stage.

Seven different polyembryonic species have been studied in part or completely by the writer. These are: *Platygaster hiemalis* and *P. vernalis*, parasites of the Hessian wheat fly *Phytophaga destructor; P. variabilis*, a parasite of a rosette shaped terminal gall on goldenrod caused by the Cecidomyid *Rhopalomyia carolina; Copidosoma gelechiae*, a parasite of an elliptical gall on goldenrod made by the lepidopteron *Gnorimoschema gallaesolidaginis; C. thompsoni*, a parasite of *Nothrix senticetella; C. boucheanum*, a parasite of *Gelechia pinguinella**); and *Cop; dosoma truncatellum*, which is parasitic on the cabbage looper *Autographa brassicae*. These species demonstrate polyembryony from the most simple type in which only two individuals (twins) are developed from one egg to the more complex type where as many as 1500 to 2500 individuals are produced from a single egg or a pair of eggs.

It would appear best to refer to each species studied, to compare them with each other and with species studied by other workers.

1. *Platygaster hiemalis*.

This parasite oviposits from four to eight eggs at one insertion of the ovipositor in the host egg during the fall of the year, — occasionally it will oviposit in a larva which has just hatched from its egg. The eggs develop both monembryonically and polyembryonically, but when the latter method is followed only twin adults are developed. An average of 6.31 individuals, often representing both sexes, are reared from the host puparia. There is but one generation developed each year.

Some of the eggs of a group of four to eight found in a host egg, and known to have been placed there by a fertilized female during one insertion of the ovipositor, contain a sperm while others do not, thus indicating the ability of the female to control insemination. Mixed broods of adults (males and females) are thus accounted for, the males developing from unfertilized eggs and the females from fertilized eggs.

Maturation of the egg takes place during the first two days after deposition in the host egg. It is indentical in fertilized and unfertilized eggs. The polar bodies are not thrown off, but are retained in the polar (anterior) region of the egg, where, together with a differentiated portion of the cytoplasm of the egg, they give rise to a pair of nuclei later known as paranuclear masses; the latter masses develop within a membrane or envelope which, because of its function, is known as the trophamnion.

About the end of the first day of development or early in the second day the parasite egg shows two well defined regions, — the trophamnion with its two paranuclear masses, and the embryonic region which is a more lightly stained spherical area lying in the trophamnion and containing a single embryonic or cleavage nucleus. During this development the egg has increased about 20 percent in volume and is henceforth known as a parasite body.

---

*) *C. thompsoni* and *C. boucheanum* are parasites found in France. Host larvae parasitized by these species were kindly sent to the writer by Dr. H. L. Parker.

While maturation and differentiation of the two regions takes place, the eggs become dispersed in the host egg and become lodged against the host tissues such as the salivary glands and fat bodies. These host tissues invest the parasite bodies, — at least in most instances. Such eggs or parasite bodies as become completely invested will develop embryos. Others that do not become entirely invested are likely to develop only partly and become aborted, resulting then in the production of forms that have been called pseud-embryos and pseudo-larvae.

Cleavage of the segmentation or embryonic nucleus takes place in the parasite body about the second day. Two nuclei and then four nuclei are formed in the embryonic region. Meantime the two paranuclear masses in the trophamnion become elaborated and divide to form four smaller masses. Until this stage is reached the development of all parasite bodies is identical, so far as has been observed. At this point, however, the four embryonic nuclei group themselves in pairs in some parasite bodies, the embryonic region likewise dividing into two equal halves. In other parasite bodies, there is no division of the embryonic region, nor is there any grouping in pairs of the embryonic nuclei. In the former case the division and grouping results in the development of twin embryos (polyembryony), while in the latter case a single individual is developed monembryonically.

A study of the preparations leaves no doubt as to the two methods of development occurring in the same species and even in the same group of parasite bodies in one host, since the parasite bodies become isolated and surrounded by host tissues in such a way that they show no former relationship with each other. In such parasite bodies where twin parasites are due to develop and two embryonic regions are apparent, both are invested by the same common trophamnion. At a later stage, however, the trophamnion divides, half of it passing to one embryonic region and the other half to the second embryonic region. Each region containing its two (and later four) embryonic nuclei, and surrounded by its own trophamnion containing its two paranuclear masses, develops independently through the blastula and the later embryonic stages to form a primary parasite larva. This method of development in principle, at least, is exactly the method followed by other polyembryonic species that produce from 15 to 1500 or 2500 individuals from one egg. About the only essential difference is the continued division and subdivision of the embryonic nuclei to form a larger number (up to 100 or 200), before they arrange themselves to become invested with a portion of the elaborated trophamnion and to become separated, one group from another, so that they can develop through the blastula and later embryonic stages to the primary larval stage.

While the embryos are passing through the blastula and organogeny stages, they are of course increasing in size. There is no yolk material, hence tissue building elements are secured from the trophamnion which in turn, with the aid of the paranuclear masses, must and does secure the necessary nutriment from the host tissues. This particular phase of tissue building is not peculiar alone to polyembryony, for it is typical of the most specialized type of some parasitic insects that develop monembryonically. Indeed, it may be more prevalent in monembryonically developing parasitic insects than is now supposed. It will likely be found in all such species

whose eggs are very small in size. Such eggs are devoid of yolk as a fundamental tissue building material for a developing embryo; instead, there is substituted a lesser amount of egg cytoplasm which is able to function as a trophamnion having the power to transform elements in host tissues to a condition where they are absorbed by the embryo through its stages of development until it is a primary larva, and able to secure its own food by direct feeding.

While the trophamnion is thus functioning comparatively small amounts of elements are taken from the host larva which at this stage is small. Indeed the amount is so small that the host is apparently not affected by the presence of the slowly developing embryos. The host larva is thus permitted to feed and reach full larval size, at which time it can furnish the greatest quantity of food for any parasitic forms that it contains. Then when the host larva has reached full size the primary parasite larvae become released in the body cavity of the host and feed upon its tissues — the feeding resulting in the death of the host and the maturity of the parasite larvae. The development of the parasites and the host are thus perfectly synchronized to the distinct advantage of the parasites.

Such parasite bodies of *P. hiemalis* of the four embryonic nuclei stage as do not divide to form two distinct embryonic regions containing two embryonic nuclei each, proceed to develop a typical blastula by subdivision of the nuclei. As this development advances the trophamnion enlarges, its paranuclear masses splitting up into many smaller masses. The parasite embryo then passes through the stages of organogeny at about the same time as those that have developed by the twinning process.

Only one additional step is necessary in the development of twin parasites and that is the separation of one embryonic region containing two or four nuclei from the other identical region. This is brought about at the four or eight embryonic cell stage by an infiltration of the trophamnion and the surrounding host tissues between the twin embryonic areas. Henceforth development is identical with the monembryonic forms. It is not unlike that shown by Marchal for the platygastrids *Synopeas rhanis*, *Trichasis remulus* and *Platygaster ornatus*.

The embryos of *P. hiemalis* complete their development in late spring. The larvae then commence feeding within the host larvae and devour the entire content of it. This is done in a week or ten days. The larvae remain within the body wall of the host during early summer when each forms a chamber or cell in which it pupates. The parasites remain as pupae in their individual chambers within the carcass of the host and emerge simultaneously as adults in early autumn to oviposit in the eggs of the Hessian wheat fly, a brood of which likewise emerges at the same season of the year.

2. *Platygaster variabilis.*

This species is parasitic on the Cecidomyid *Rhopalomyia carolina*, which makes a terminal rosette gall on goldenrod. The adult parasites emerge during September and immediately deposit their eggs in the eggs of the host. There is but one brood each year.

Like *P. hiemalis* it deposits from four to eight eggs in a host egg. Each egg apparently develops twins, though the species has not been sufficiently

studied as yet to determine as to the possible development by monembryony of some of its eggs. Thus far it appears to resemble the development of *P. hiemalis* so closely as not to be worthy of further treatment at this point.

3. *Platygaster vernalis.*

This species is likewise parasitic upon the Hessian wheat fly. It develops only by the polyembryonic process, one egg giving rise eventually to approximately eight individuals. There is but one generation annually. The adult parasites emerge from their pupal chambers within the host carcass in spring and oviposit in the eggs of the spring brood of Hessian flies. The embryonic larval and pupal stages are completed by late August.

A single egg is deposited at each oviposition in the egg of the host It is placed in such a manner that it always becomes lodged in the mid-intestine of the host where development to the primary larval stage of the parasites is invariably completed. Should it become lodged in another part of the host, development of the parasite body is inhibited. At times one or two female parasites may oviposit more than once in the same host egg. A few hosts have been observed to contain two or at most three parasite bodies which had developed from as many eggs. As a rule one or two of three parasite bodies will become aborted in the early egg stage or before the blastula stage is reached.

Development of the egg begins immediately whether it is fertilized or not. Maturation is generally similar to that of *P. hiemalis.* When the egg is one to two days old, it exhibits two paranuclear masses in the anterior region which are the product of the polar bodies. These are located in the trophamnion. In the posterior end of the egg is to be found the embryonic nucleus in a lightly stained area, known as the embryonic region.

The embryonic nucleus divides until approximately sixteen daughter nuclei are evident. Each nucleus then becomes differentiated from the other by a cell wall enclosing with the nucleus a small amount of the embryonic cytoplasm. This differentiated area gives rise directly to a parasite and at this stage is known as a germ.

Meantime the trophamnion with its paranuclear masses becomes elaborated. It is able to secure nourishment for the growth of the parasite body from the liquid food ingested into the stomach by the growing host larva.

Growth of the trophamnion permits the unicelled germs to divide and subdivide until each reaches the blastula stage. The parasite body is then no longer spherical and located in one end of the host's stomach, but becomes elongated until it almost fills the mid-intestine. Organogeny of the parasites follows, whereupon the trophamnion becomes vacuolated, thinned, and finally breaks down to release the parasites in their primary larval stage.

The presence of the parasite body in the stomach of the host does not apparently affect it, for the host larva reaches full size just about the time the primary larvae begin to feed directly upon its tissues. The stomach is first destroyed, followed by all the other tissues of the body. The parasite larvae, when fully grown, pupate within chambers inside the host puparium and emerge therefrom in spring.

The adults of a brood are nearly always of the same sex. Mixed broods (of both sexes) develop from an unfertilized and a fertilized egg that happen to be placed in the same host egg.

The development of *P. vernalis* represents an advance step over that of *P. hiemalis* and *P. variabilis.* While more complex than these species, its development is not as advanced as that of other species to be described later.

4. *Copidosoma gelechiae.*

This hymenopteron is a parasite of the lepidopteron *Gnorimoschema gallae-solidaginis,* maker of an elliptical gall on the stems of Solidago spp. Both parasite and host are single brooded. Either fertilized or unfertilized adults deposit a single egg at one insertion of the ovipositor in a host egg during autumn. Occasionally a female parasite will revisit a host egg under experimental conditions and deposit a second egg in the same host egg, but usually the female parasite seems to be able to determine whether or not the host egg has been attacked previously.

Since this species develops an average of 163 adults from a single egg, it is natural to expect a more complex type of development than that described for the preceding species, but not as complex as that to be described briefly later for *C. truncatellum,* a species that develops from 1500 to 2500 individuals from one egg.

The cleavage nucleus, whether fertilized or not, divides to form two, then four, and then seven embryonic nuclei. The fourth embryonic nucleus of the second division does not keep pace in its division with the other three because of the presence in its cell of a cyptoplasmic inclusion known as the germ-cell-determinant. The embryonic nuclei continue to divide over a period of a few weeks (during late autumn) and then remain in a dormant condition until spring. They are to be observed in a differentiated portion of the parasite body which is the embryonic region. This region in turn becomes invested by the trophamnion and its paranuclear masses, which developed from the differentiated polar region and polar bodies of the parasite egg.

Meantime the only development made by the host is embryonic, and it passes the winter as a well developed larva ready to emerge from the egg early in spring. During this period the parasite body is found in almost any portion of the host.

Prior to spring the parasite body has increased little in size. Its volume is about twice that of the original egg, but with the emergence of the young host larva from the egg and its feeding within the stem of a new goldenrod shoot, the parasite body becomes active and grows more rapidly.

The embryonic nuclei, of which there are from 100 to 200, now become isolated one from another. Each is surrounded by a portion of the embryonic cytoplasm. Each nucleus, together with its bit of cytoplasm then becomes invested by a cell wall or membrane. There is thus formed an embryonic cell, which represents the germ stage. The trophamnion with its paranucleus then invests each germ. Since the groups of germs are held together by a portion of the trophamnion and host tissues, the parasite body is regarded as a polygermal mass.

The original nucleus of each germ now divides to form four, eight, etc., daughter nuclei. The germs, at least some of them, then divide to form two

daughter germs. Division continues into the morula stage in some instances where a germ did not divide when composed of only about 16 nuclei. The result is the formation of from 175 to 250 germ or morula groups of nuclei each of which should develop into an embryo, then to a parasite larva, and finally into an adult parasite. This number of germs or morulas is greater than the avarage of 163 individuals reared from a host larva. The others perish or fail to complete their development, because they do not become invested by a sufficient amount of the trophamnion, so they could be nourished through to the primary larval stage, or because division of the germs and morulas has been carried too far and they do not contain sufficient component elements to permit of their complete development. There are thus produced along with approximately 163 healthy embryos or larvae, nearly a hundred more embryos or larvae that become aborted. These have been termed pseudogerms, pseudembryos and pseudolarvae.

It is now necessary to note the breaking up of the polygermal mass into secondary masses and the final disjunction of each embryo within the polyembryonic mass.

The polygermal mass fragments by the infiltration of the trophamnion and host tissues into secondary masses. This fragmentation continues until each embryo is separate structurally from all other embryos, though they are all bound together by a cyst of host tissue, — usually a fat body. Each germ or morula thus formed increases in size because of the trophamnion surrounding it and because of elements gathered from the interembryonal matrix of host nuclei and fat cells. When organogeny of the embryos is completed the embryos straighten out from their "U"-shape as fully formed primary larvae. The trophamnion having completed its function becomes a thin membrane. The distention of the primary larvae ruptures the weakened cyst of host tissues, thus setting free the primary larvae in the body cavity of the host.

By this time (during June) the host larvae have approached full size. The primary parasite larvae then feed upon the blood and all other tissues of the host, devouring all save the chitinous portions. When the larvae are mature they completely fill and distend the host carcass. Each larva pupates in a chamber. All the adults emerge simultaneously during August or September, first into the gall and then into the open through an exit provided for the adult moth by the host larva.

5. *Copidosoma truncatellum.*

In this species, as shown by Silvestri and Patterson and as confirmed by the writer in his own preparations, polyembryony is exhibited in the most specialized form yet known. From 1600 to 3000 individuals are developed in host larva of the cabbage moth, *Autographa brassicae.* This enormous number is due to the larger size of the host, the smaller size of the adult parasites when compared with *C. gelechiae,* and the fact that the species has adapted itself to the accommodations afforded by its host by a continued subdivision of the germinal stages to form a greater number of embryos.

In the species studied by the writer, one or two eggs are deposited at each insertion of the ovipositor in the host egg. In about 49% of the instances two eggs are placed side by side. In 80% of the two egg oviposi-

tions one of the eggs contains a sperm while the other is unfertilized, though both eggs originated from a female parasite known to have copulated with a male.

The eggs undergo immediate development and a brood of parasites may be matured in four or five weeks, there being two or three generations a year, or as many as there are of the host.

As in other polyembryonic species a polar and an embryonic region become differentiated. The embryonic nucleus divides to form a syncytium of many nuclei, perhaps 300, within a week after oviposition. This syncytium becomes surrounded by a trophamnion containing paranuclear masses of polar region and polar body origin respectively. The parasite body is commonly observed within a ganglion of the main nervous system of the host or otherwise completely invested by host adipose tissue.

Before passing to the later stages of development it should be noted that there is a germ-cell-determinant (the oosoma of Silvestri) present in the egg. This passes to one of the early embryonic cells and seems to slow up the daughter embryonic cells arising from the cell receiving it. Definite traces of the determinant are lost just as they are in *C. gelechiae.* Silvestri believes, however, that there exists a relationship between the cell receiving the determinant and the development of aborted larvae, termed by him asexual larvae.

The parasite body containing the embryonic nuclei increases in size through the absorption of host elements by the nucleated trophamnion. Germs are formed within it essentially as in *gelechiae.* These divide to form secondary or daughter germs, or they develop to the early morula stage where they divide. Meantime the polygermal mass breaks up into secondary masses, or groups of germs may become free of the main mass and are then carried to all parts of the cavity of the host larva. Each germ is completely invested by a part of the trophamnion, though it is not as yet structurally separated from other germs.

The polygermal mass has thus become fragmented, while the free secondary germ masses become invested by host tissues against which they have been lodged as they were carried about in the cavity of the host by the blood stream. This dispersal of groups of germs is unique in *C. truncatellum* and is not characteristic of any species described above. It is simply an advance step toward perfect adaptation, and is one of the essentials necessary for the development of the enormous number of parasite larvae in one host.

Later stages of development of the germs through the morula and later embryo stages are about as in other species. The embryonic nuclei multiply by mitotic division. Each germ or morula becomes completely surrounded by a part of the trophamnion, and finally becomes completely disjoined from any other individual embryo in the organogeny stage. When organogeny is completed, the trophamnion needs to function no longer, whereupon it persists only as a thinned membrane to be torn open and devoured by the primary larva when it begins to feed directly upon the host tissues.

There is observed in the cavity of the host, however, from one to four weeks after it has hatched from the egg, a number of advanced embryos and parasite larvae, — from 10 to 60 in number, and

at times a few more. These are co-developing as conspicuous fully developed embryos or primary larvae side by side with the germ stages described above, though the trophamnion surrounding these conspicuous embryos is distinct from that surrounding the more numerous germs. These embryos or free larvae are the asexual larvae first described by Silvestri. They develop in advance of the sexual larvae. They never feed upon the host tissues, but begin to disintegrate either when they are passing through the stage of organogeny or just after they have uncurled their bodies as primary larvae. They have apparently no function. Should there be any portion of their bodies left in the host when the primary larval stage is reached by the sexual forms, the latter will devour the asexual forms along with the host tissues.

The primary sexual larvae moult at least once while feeding. The dispersal of secondary masses of germs has been the indirect means of scattering the larvae throughout the body cavity of the host larva, which at this time has reached full size and is about to pupate. The host larva does succeed in spinning a thin cocoon about its body, but often perishes because of the feeding of the parasites before the cocoon is completed.

At this stage the larval parasites are in close contact with each other within the host, whose tissues have been entirely devoured. Each larva forms a chamber in which it pupates. In a week or ten days all of the adult parasites emerge simultaneously. They are ready to mate and oviposit immediately after emergence.

6. *Copidosoma thompsoni* and 7. *C. boucheanum.*

Host larvae parasitized by these two species have been sent to the writer by Dr. H. L. Parker, of the U. S. European Parasite laboratory in France. They have been studied only in a preliminary way. A thousand or more individuals develop from one egg in both species. Both likewise demonstrate the presence of asexual or abortive larvae co-developing with sexual germs and morulas in host larvae that are about one third grown. In a general way the development of these species may be said to be similar to *C. truncatellum.*

The orgin of Polyembryony.

It is quite evident that the twinning of an egg is just one step in advance of a very highly specialized form of embryological metamorphosis exhibited by some of the parasitic hymenopters that develop in the egg stage of their hosts. This is demonstrated by the origin, presence and similar function of the trophamnion which is common to both monembryonic and polyembryonic species.

The monembryonic egg parasite has one advantage, — that of completing its metamorphosis to the adult stage in a few days, while the polyembryonic species requires weeks or nearly a year to mature a generation. In the former species the size of the host egg is so small and contains so little food that it can accommodate only one, two, or at most three parasite larvae (e. g. *Trichogramma).* The polyembryonic species, on the other hand, begin exactly as do the monembryonic egg parasites, but instead of their embryonic nuclei entering directly upon the blastula stage and devel-

oping a larva in a few days, the nuclei subdivide, and the trophamnion becomes more elaborated and operates on a more extensive scale; meantime the host larva is permitted to hatch from the egg and feed so that it approximates the mature larval stage. Thus a similar host egg through its subsequent larval stages may be the means of maturing 1500 to 2000 adult parasites by polyembryony instead of one, two or three parasites maturing in the host egg by monembryony.

The close relationship between monembryonic and polyembryonic insects with regard to the origin of polyembryony is exhibited in the three species of *Platygaster*, — *herricki*, *hiemalis* and *vernalis*. All are parasites of the Hessian wheat fly and oviposit in the egg of the host. All species occur in the same locality. *P. herricki* develops only by monembryony, and as an adult is larger than the other two species. *P. hiemalis* develops both monembryonically and by the twinning process, but the female deposits from four to eight eggs in a host egg which give rise to about the maximum number that the host larva can mature. *P. vernalis* develops only by polyembryony in its generalized form, depositing one egg that gives rise to 15 or 20 adults, the maximum number that the host larval stage can accommodate.

It appears safe to conclude then, that all polyembryonic insects originally developed by monembryony, and that, through polyembryony, the species have learned to reproduce their kind in greater numbers. This, in the opinion of the writer, is exactly what all insects are striving to do in various ways.

The Asexual Larvae.

Asexual larvae are apparently present only in species that develop large numbers from a single egg, that is, 1000 or more, and in species that have the habit of depositing two eggs at a single insertion of the ovipositor. According to Silvestri they lack germ cells, the respiratory system and the circulatory system. My studies show that at least in *C. thompsoni* the circulatory system is present, but the germ cells and respiratory system are wanting. The respective systems of this type of larva are difficult to trace, since one deals only with a fully developed embryo and not a larva that has taken food and has grown. It should be recalled that the asexual larvae begin to distingrate just after they uncurl in the embryonic capsule in which they developed.

They develop in advance of the sexual larvae, and, should they be capable of completing their development, they would destroy the host when it is only one third or one half grown. As a result there would be developed only 30 to 60 parasites in a brood instead of the customary 1500 to 2500, which the host, because of its size, is capable of maturing when it is fully grown.

The so-called asexual larvae are, therefore, in the opinion of the writer, forms of larvae originating from parts of the polygermal mass that have not as yet learned to continue their subdivision into secondary or tertiary germal masses. When they arrive at the primary larval stage with the host only partly grown, they are unable to feed, or at least do not feed directly upon the host tissues. To do so would prohibit the development of the more numerous sexual larvae that mature just as the host larva completes its development and reaches its maximum size. If the 30 to 60 asexual

larvae did succeed in taking food and maturing to the adult stage, it would appear that such adults would be about ten times the size of the sexual adults.

Sex Ratio.

This subject has been fully discussed by the writer (26), wherein it has been shown that a fertilized egg produces a brood of female parasites, an unfertilized egg a brood of males, and that a mixed brood is the product of a fertilized and unfertilized egg which have been placed in the host egg the same female or by two females.

The Structure of the Pupal Chambers.

There has been some discussion as to the origin and structure of the chambers or cells in which polyembryonic parasites pupate. It will be remembered that the larvae are in close contact with each other when fully grown and when the contents of the host larva have been completely devoured. At that time they cause the host cuticula to be expanded to twice its normal size. They assume no common position in the host carcass, but are generally parallel. Their pupal chambers are not unlike a honeycomb.

The larvae shrink in size after they are fully fed and the host is entirely devoured. When shrinking the outer layer of the cuticula is shed, — in reality they moult. This cast cuticula is not crumpled and forced to the rear of the body, but remains over the larva and hardens to form the wall of a pupation chamber just as in the Diptera. At the time the cuticula is separated from the larva, the passage way from the mid-to the hind-intestine is opened and defecation of the contents of the mid-intestine results. The larvae thus become smaller and are able to transform to pupae in their chambers after another moult. This moulted skin is found in the chamber along with the excretory pellets. It may be possible that the cast cuticula is hardened by a secretion from the salivary glands, since the larvae invariably appear to be bathed in a colorless liquid; just after the cuticula is shed, however, there is no evidence of a silk lining inside the pupal chambers.

Summary.

Polyembryony in insects begins as a twinning process as described for some of the eggs of *Platygaster hiemalis*. Other eggs of this species develop monembryonically and these demonstrate the most specialized type of monembryony thus far described. In this type there is no yolk to furnish nutriment for the developing embryo; instead, a part of the egg together with the polar bodies forms a nucleated envelope that appears able to extract nutritive elements from the host tissues and pass them to the embryo to aid in its development. This nucleated envelope, known as the trophamnion, becomes more elaborated and specialized in the species as they produce a greater number of individuals from one egg.

A decided evolutionary process is evident from the highly specialized monembryonic species on through those that produce twins, 14, 24, 163 and 1500 to 2500 individuals from a single egg.

Polyembryony begins when the fertilized or unfertilized egg nucleus divides and subdivides to the end that the daughter nuclei, whatever their number, give rise directly or indirectly to embryological units called germs.

The germs metamorphose to the morula, blastula and organogeny stages, and then into the primary larva. Under conditions of monembryonic development the early daughter nuclei would give rise directly to the embryonic layers.

Because polyembryony is not yet perfect, pseudo or abortive forms are developed along with perfect forms. The former perish while the latter mature. This lack of perfect development is also responsible for the production of 'asexual' larvae in those species that develop 1000 or more individuals from a single egg.

All polyembryonic species thus far known are parasitic upon other insects. They oviposit in the host egg. The larvae mature through the pupal and adult stages within the fully grown host larvae. The adults of a brood emerge simultaneously from the carcass of their host. When such adults are all of the same sex they probably developed from one egg, — when both sexes are represented, the adults very likely originated from two eggs, one of which was fertilized while the other was unfertilized.

Literature on Insect Polyembryony.

1. Bugnion, E. Recherches sur le développement postembryonnaire, l'anatomie et les moeurs de l'Encyrtus fuscicollis; in Recueil Zool. Suisse, T. 5, pp. 435—536; 1891.
2. Gatenby, J. Bronte. Polyembryony in parasitic hymenoptera: A review; in Quart. Journ. Mic. Sci., N. S., vol. 63, pp. 175—196; 1918.
3. Howard, L. O. The methods of pupation among the Chalcididae; in Insect Life, Vol. 4, pp. 193—196; 1891.
4. id. Polyembryony and the fixing of sex; in Science, N. S., Vol. 24, no. 625, pp. 810—818; 1906.
5. id. Two new instances of Polyembryony among the Encyrtidae; ibid., Vol. 49, pp. 43—44; 1919.
6. id. An obvious new case of polyembryony; ibid., Vol. 62, p. 308; 1925.
7. Kornhauser, S. I. The sexual characteristics of the membracid *Thelia bimaculata* Fabr. I. External changes induced by *Aphelopus theliae* (Gahan); in Journ. Morphology, Vol. 32, pp. 531—636; 1919.
8. Leiby, R. W. The polyembryonic development of *Copidosoma gelechiae*, with notes on its biology; ibid., Vol. 37, pp. 195—285; 1922.
9. id. and Hill, C. C. The twinning and monembryonic development of *Platygaster hiemalis*, a parasite of the Hessian fly; in Journ. Agr. Research, Vol. 25, pp. 337—349; 1923.
10. id. and Hill, C. C. The polyembryonic development of *Platygaster vernalis*; ibid., Vol. 28, pp. 829—839; 1924.
11. id. The origin of mixed broods in polyembryonic Hymenoptera; in Annals Ent. Soc. Amer., Vol. 19, pp. 290—299; 1926.
12. Marchal, Paul. Les Cécidomyies des céréales et leurs parasites; in Ann. Soc. Ent. France, T. 66, pp. 1—105; 1897.
13. id. Recherches sur la biologie et le développement des hymenoptères parasites. I. La polyembryonie spécifique ou germinogonie; in Arch. Zool. Exp. et gén., T. 2, sér. 4, pp. 257—335; 1904. II. Les Platygasters; ibid., T. 4, sér. 4, pp. 485—640; 1906.
14. Martin, Friedrich. Zur Entwicklungsgeschichte des polyembryonalen Chalcidiers *Ageniaspis (Encyrtus) fuscicollis*; in Zeits. f. Wiss. Zool., Bd. 110, S. 419—479; 1914.
15. Patterson, J. T. Observations on the development of *Copidosoma gelechiae*; in Biol. Bull., Vol. 29, pp. 333—373; 1015.
16. id. Studies on the biology of *Paracopidosomopsis*. I. Data on the sexes; ibid., Vol. 32, pp. 291—305; 1917. III. Maturation and fertilization; ibid., Vol. 33, pp. 57—67; 1917. IV. The asexual larvae; ibid., Vol. 35, pp. 362—377; 1918.
17. id. Polyembryony and sex.; in Journ. Heredity, Vol. 10, pp. 344—352; 1919.
18. id. Sex ratios in *Platygaster*; in Amer. Nat., Vol. 55, pp. 180—183; 1921.

19. id. The development of *Paracopidosomopsis;* in Journ. Morph., Vol. 36, pp. 1—69; 1921.
20. id. Polyembryony in animals; in Quart. Review Biology, Vol. 2, pp. 399—426; 1927.
21. id. and Hamlett, G. W. D. Haploid males in *Paracopidosomopsis;* in Science, Vol. 61, p. 89; 1925.
22. Riley, W. A. Polyembryony and sex-determination; ibid. Vol. 25, p. 106, 1907.
23. Silvestri, F. Contribuzioni alla conoscenza biologica degli Imenotteri parassiti. I. Biologia del *Litomastix truncatellus:* in Ann. R. Scuola Agr. Portici, Vol. 6, pp. 3—51; 1906. II. Svilluppo dell' *Ageniaspis fuscicollis;* ibid., ser. 2, Vol. 8, pp. 1—27; 1908.
24. id. Prime fasi di sviluppo del *Copidosoma buyssoni,* Imenottero chalcidide; in Anat. Anz., Bd. 47, S. 45—56; 1914.
25. id. Struttura dell'ovo e prime fasi di alcuni Imenotteri parassiti; in Boll. del lab. di Zool. gen. e agraria della R. Scuola sup. d'Agricoltura di Portici, Vol. 10, pp. 66—88; 1915.
26. id. Contribuzioni alla conoscenza biologica degli imenotteri parassiti. V. Sviluppo del *Platygaster dryomyiae;* ibid., Vol. 11, pp. 299—326. 1911.
27. Wheeler, W. M. The effects of parasitic and other kinds of castration in insects; in Journ. Exp. Zool., Vol. 8, pp. 377—438; 1910.

Explanation of Plates VI to XII.

Platygaster hiemalis.

Fig. 1. Parasite egg immediately after oviposition, with nucleus and sperm. Compare size of egg with that of blastoderm cells of host egg.

Fig. 2. Portion of a section through a host egg cut across a group of eight parasite eggs all of which were deposited at one time. Five of the eight eggs show sections of the sperm.

Fig. 3. Parasite egg eight hours after deposition. First and second polar bodies are found close to each other in the anterior end of the egg, which is known as the polar region. Male and female pronuclei are also present.

Fig. 4. Slightly later stage than figure 3, polar bodies are fusing.

Fig. 5. Egg 12 hours old. Polar nucleus elaborates in the anterior part of the egg.

Fig. 6. Like figure 5, but with male and female pronuclei close to each other in the posterior part of the egg.

Fig. 7. Male and female pronuclei about to fuse.

Fig. 8. The egg has increased in size and is henceforth known as the parasite body. During the first two days, the polar nucleus has divided to form two paranuclear masses. The polar region and the part of the parasite body surrounding the embryonic region is the trophamnion. The fused embryonic nucleus is within the differentiated embryonic region.

Fig. 9. Parasite body about three days old with two embryonic nuclei in the embryonic region.

Fig. 10. Parasite body four to five days after deposition. The two embryonic nuclei have divided to form four.

Fig. 11. Parasite body developing monembryonically while encased in a part of the host salivary gland. Four of its eight embryonic nuclei are shown.

Fig. 12. A twin germ surrounded by host tissue with two embryonic regions still encased in a common trophamnion.

All figures are enlarged about 2200 times except figure 12 which is × 1100. All after Leiby and Hill, 1923.

Fig. 13. Section trough the twinning stage of a parasite body about six days after oviposition. The embryonic region has divided, two of the four nuclei passing to each half of the twin embryonic regions. The division of the two paranuclear masses forms four similar masses. The two germs each made up of two nuclei and two paranuclear masses become structurally separated when the trophamnion and host tissues infiltrate between them. × 2200.

Fig. 14. Monembryonically developing egg in the 32-cell blastula stage with two paranuclear masses in the trophamnion. × 1100.

Fig. 15. Blastula stage of embryo. × 550. After Leiby and Hill, 1923.

Platygaster variabilis.

Fig. 16. Developing embryo in embryonic region surrounded by the trophamnion containing two somewhat spherical paranuclear masses. Much enlarged.

Fig. 17. Primary larva about to break from its trophamnion capsule. Much enlarged.

Platygaster vernalis.

Fig. 18. Host larval carcass containing ten *P. vernalis* cocoons. × 15.

Fig. 19. Fertilized egg 30 minutes after oviposition.

Fig. 20. Egg about 24 hours old, showing two polar bodies (anterior) and male and female pronuclei.

Fig. 21. Polar bodies elaborated and henceforth known as paranuclear masses. Egg 24 hours old.

Figures 19 to 21 enlarged 2200 times. All after Leiby and Hill, 1924.

Fig. 22. Fertilized egg one or two days after oviposition, with the cleavage nucleus in a differentiated embryonic region.

Fig. 23. Parasite body two to three days old. One of the paranuclear masses has divided amitotically. First division of the cleavage nucleus has produced two cleavage nuclei in a differentiated embryonic region.

Fig. 24. Section through a three day old parasite body, showing four cleavage or embryonic nuclei and four paranuclear masses.

Fig. 25. Section of a parasite body about seven days old, showing 13 of its 16 embryonic nuclei forming germs.

Fig. 26. Section through a polygerm about ten days old, showing five germs and one morula. The darker nuclei in the periphery are paranuclear masses.

Fig. 27. Aborted or pseudoparasite body, found sometimes in a host with a healthy parasite body, in the process of degenerating. Twelve days after oviposition.

Fig. 28. In toto drawing of a polyblastula with nine blastulas in the embryonic region which is covered by the trophamnion containing its dark staining paranuclear masse.

Figures 22 to 25 are × 1875, figures 26 and 27 are × 937 and figures 28 is × 275 After Leiby and Hill 1924.

Fig. 29. Section of a polyblastula 23 days old located in the chyle of the mid-intestine of the host. Portions of seven of the eight blastulas which compose this parasite body are shown. Two of the blastulas are cut through the center. This parasite body has assumed an elongate shape and now measures about one-fourth the length of the mid-intestine of the host. The paranuclear masses are shown at each end. The periphery of the drawing represents the epithelium of the mid-intestine, the lighter stippled area the chyle of the mid-intestine. × 237. After Leiby and Hill 1924.

Copidosoma gelechiae.

Fig. 30. Parasite ovipositing in host egg. Enlarged about 10 times.

Fig. 31. Carcass of host larva showing cocoons of the parasite. Enlarged about three times.

Fig. 32. Section of an unfertilized egg five minutes after oviposition. Female nucleus above and germ-cell-determinant below. × 1320.

Fig. 33. Egg at seven cell stage showing germ-cell-determinant scattered within the stipled cell, and the polar nucleus in the polar region. × 1510.

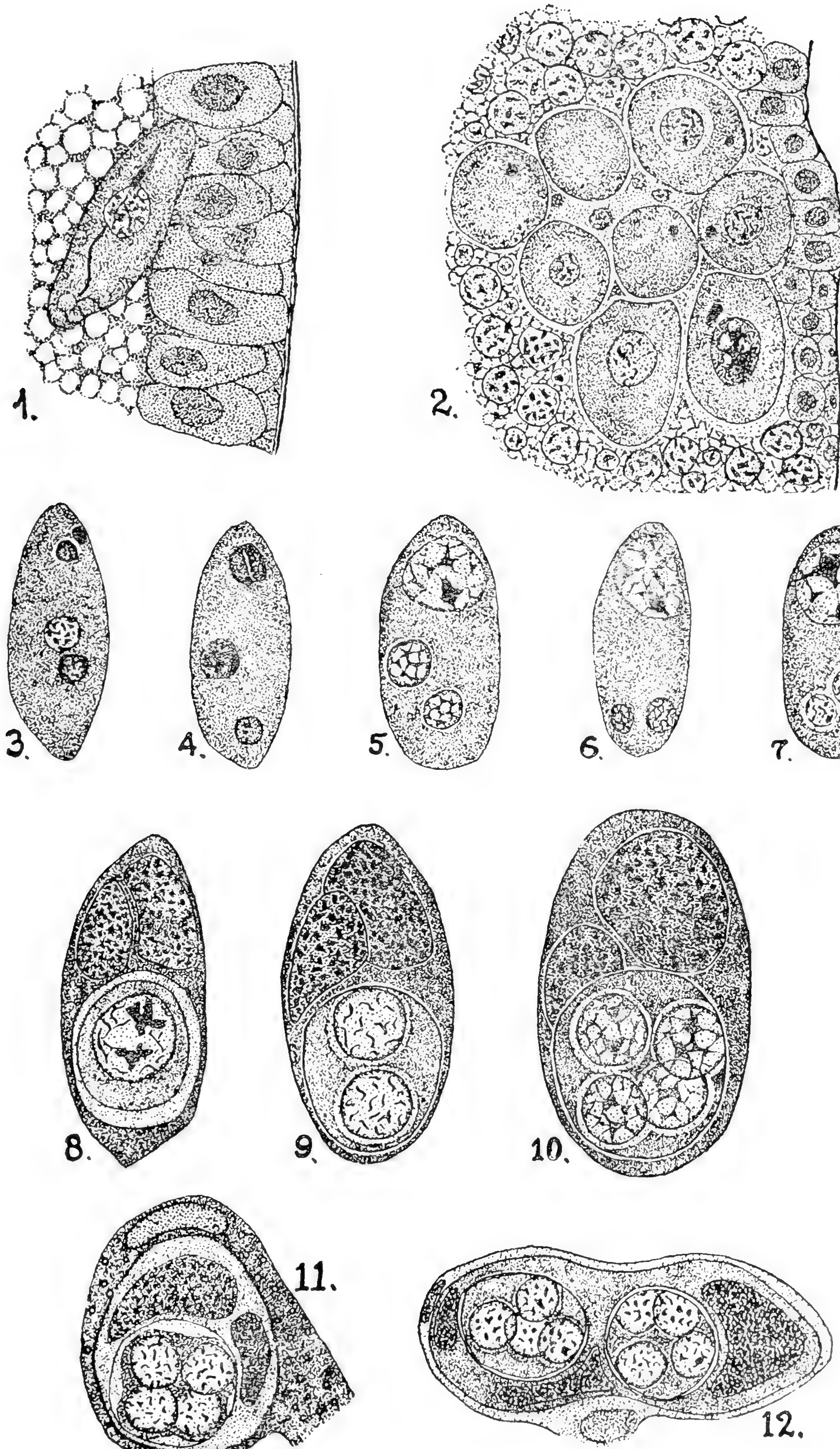
Fig. 34. En toto view of 70-hour old egg. The trophamnion with its paranuclear masses envelopes the embryonic region. × 1480.

Fig. 35. Section through a parasite body as found in an unhatched host embryo-larva in spring. The paranucleus is distributed about the embryonic plasm and nuclei. × 740.

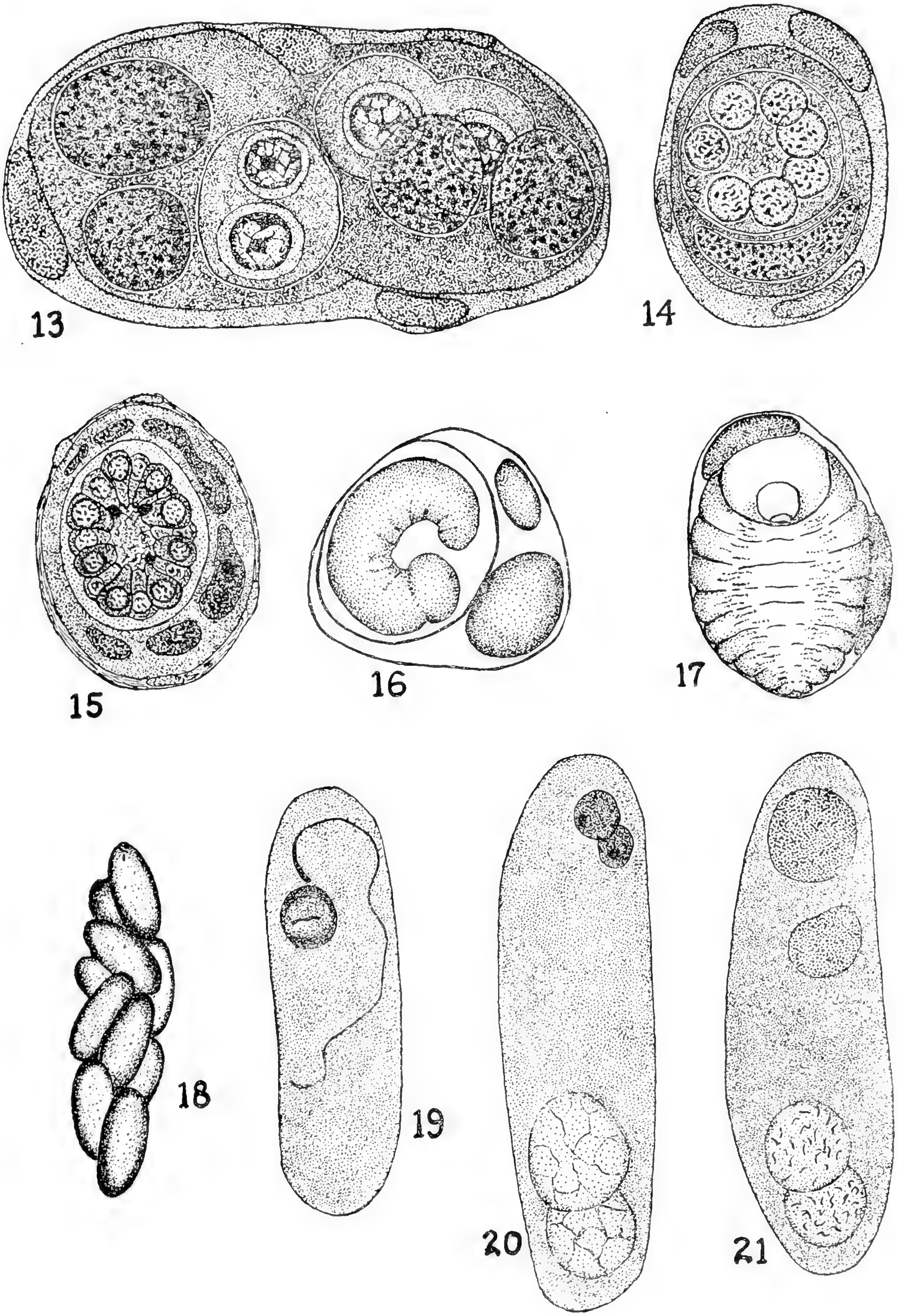
Fig. 36. Polygerm within host fatty tissue adjacent to body wall of the young host larva. × 61.

Fig. 37. Part of a section through the polygerm illustrated in figure 36, - that shown is below the horizontal line. Note the formation of the germs; the darkened area penetrating between them is the paranucleus; host tissue envelops the parasite body. × 740.

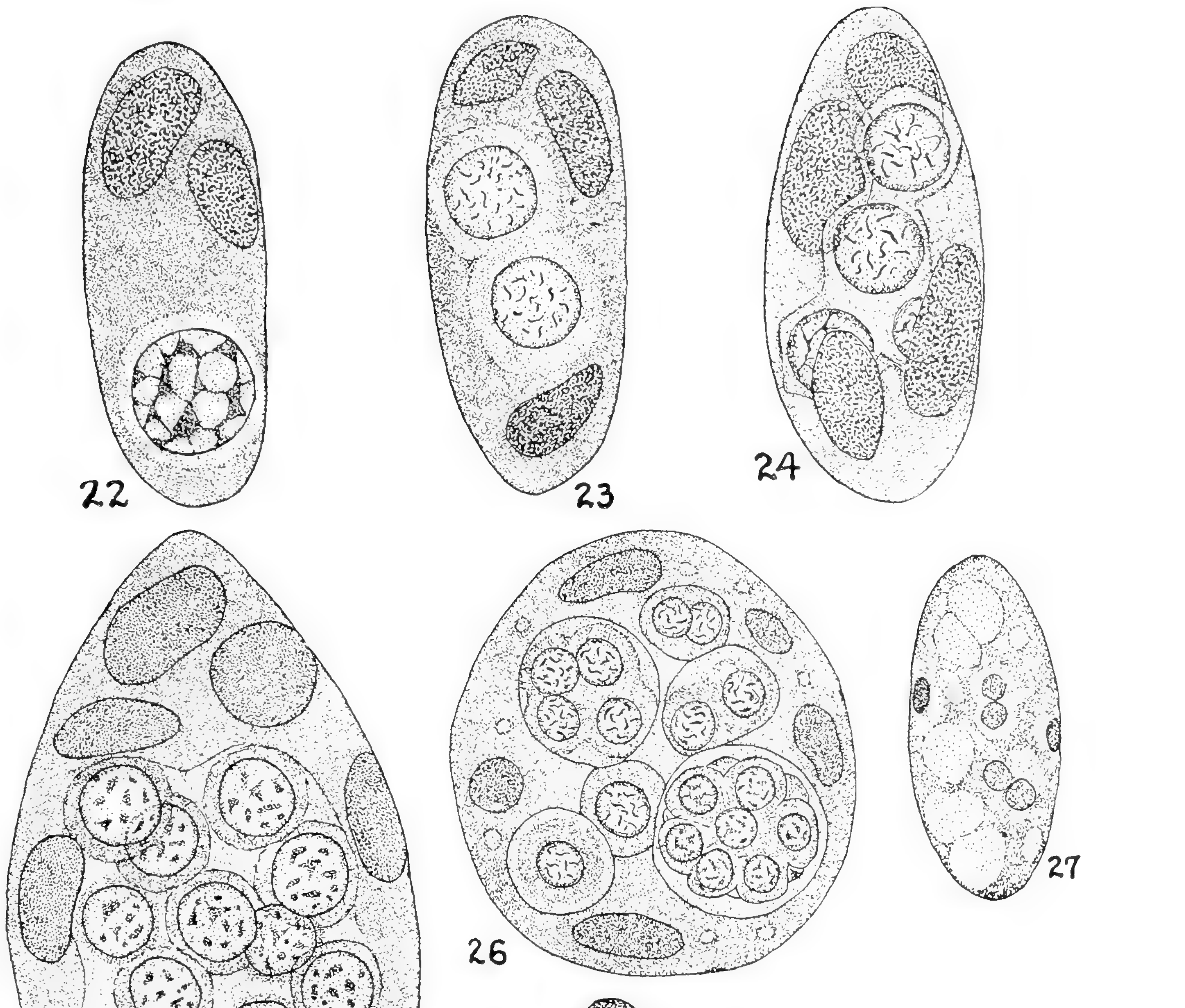
Fig. 38. Photomicrograph of a section through a polygerm showing its breaking up into secondary masses. Above is a part of the host salivary gland, and at the right a portion of a host trachea. × 161.



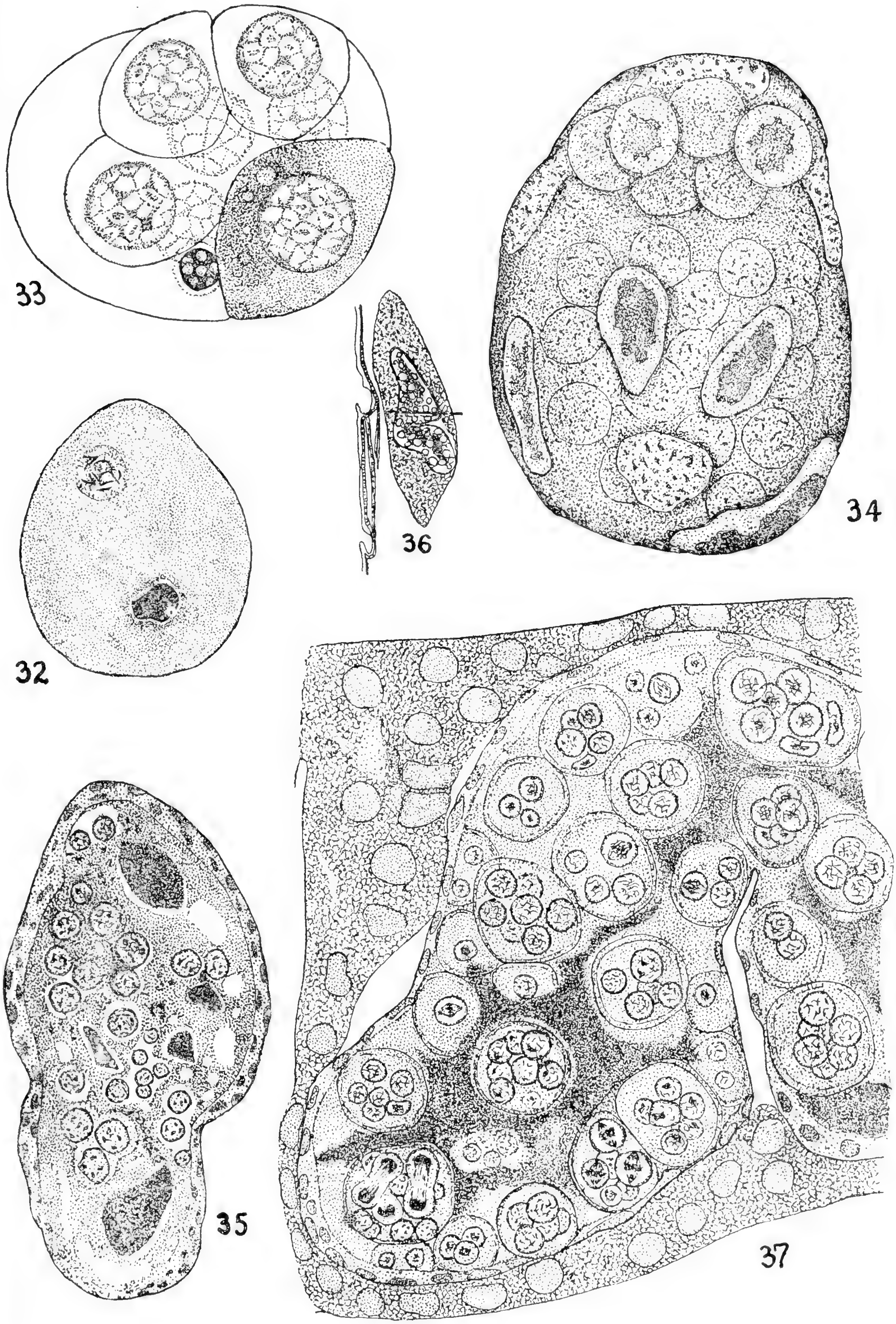
Leiby, Polyembryony in Insects.



Leiby, Polyembryony in Insects.



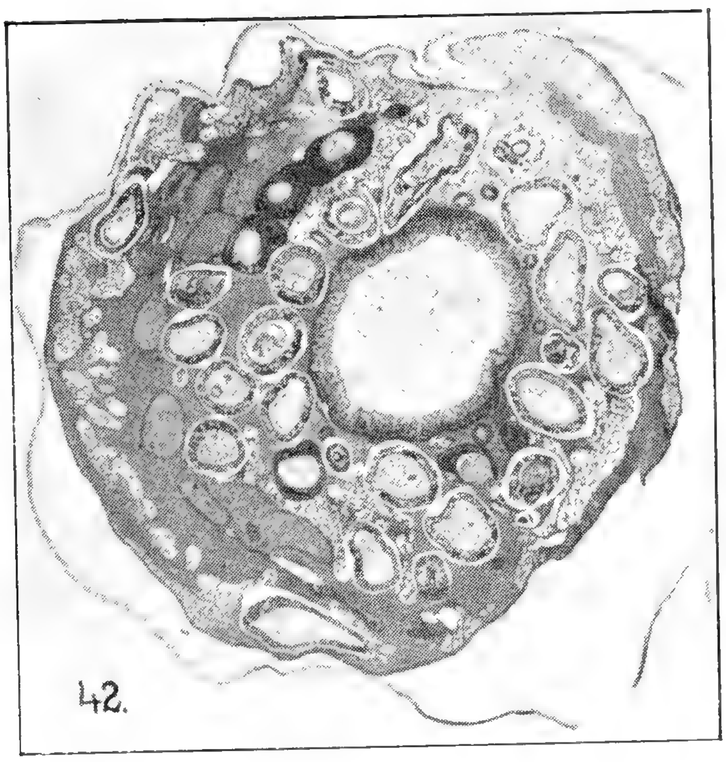
Leiby, Polyembryony in Insects.



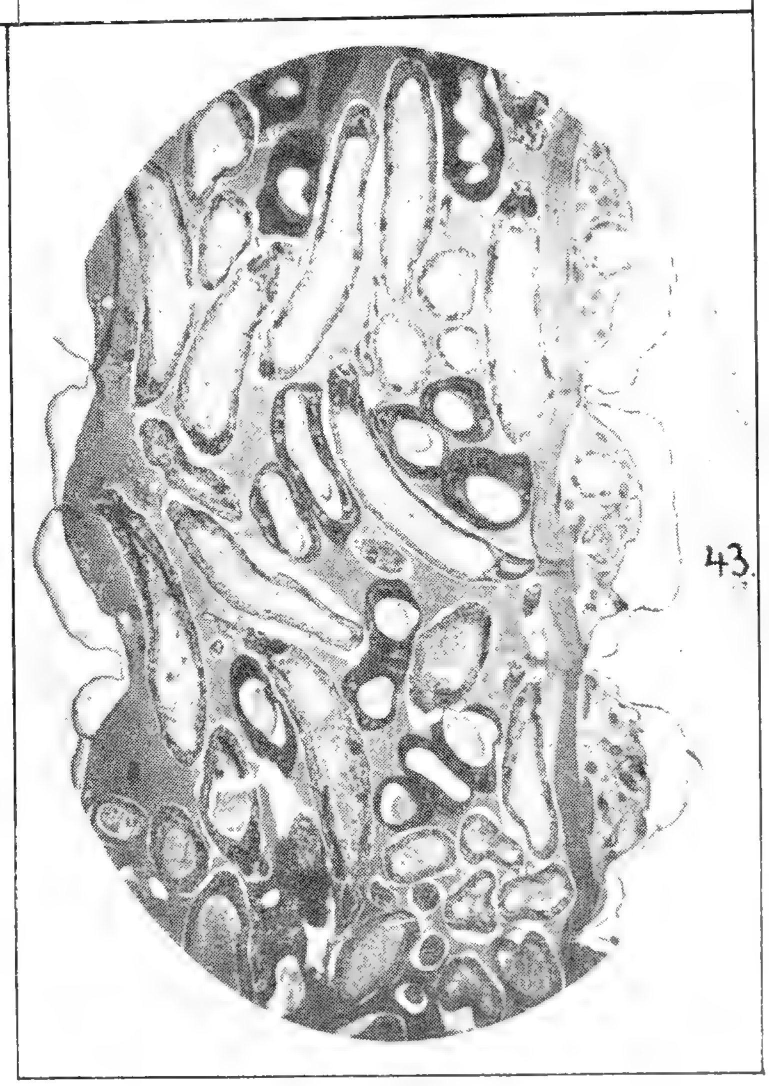
Leiby, Polyembryony in Insects.

38.

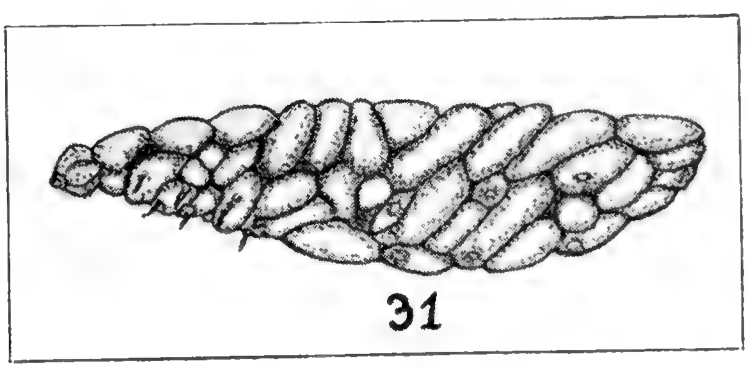
39.



42.

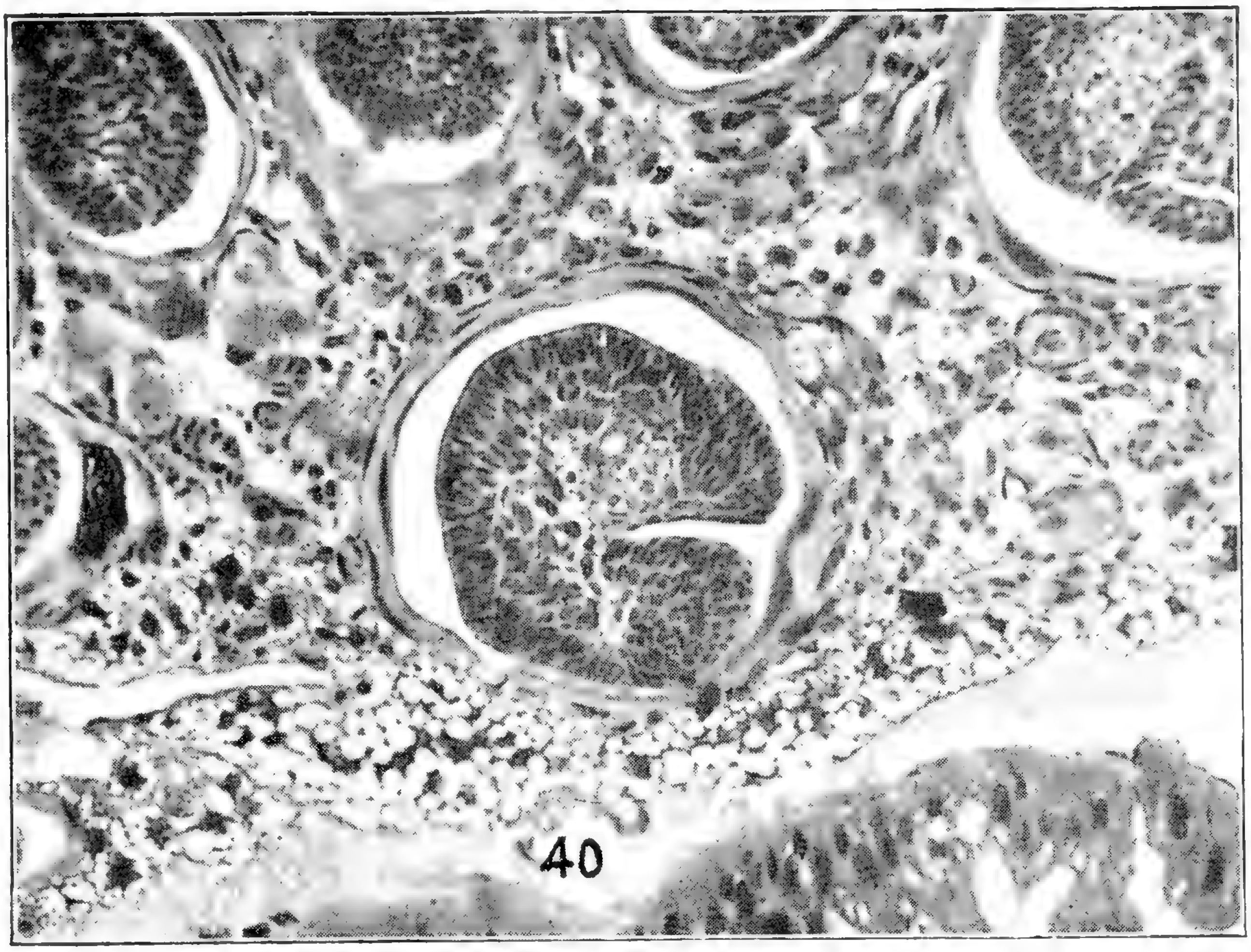


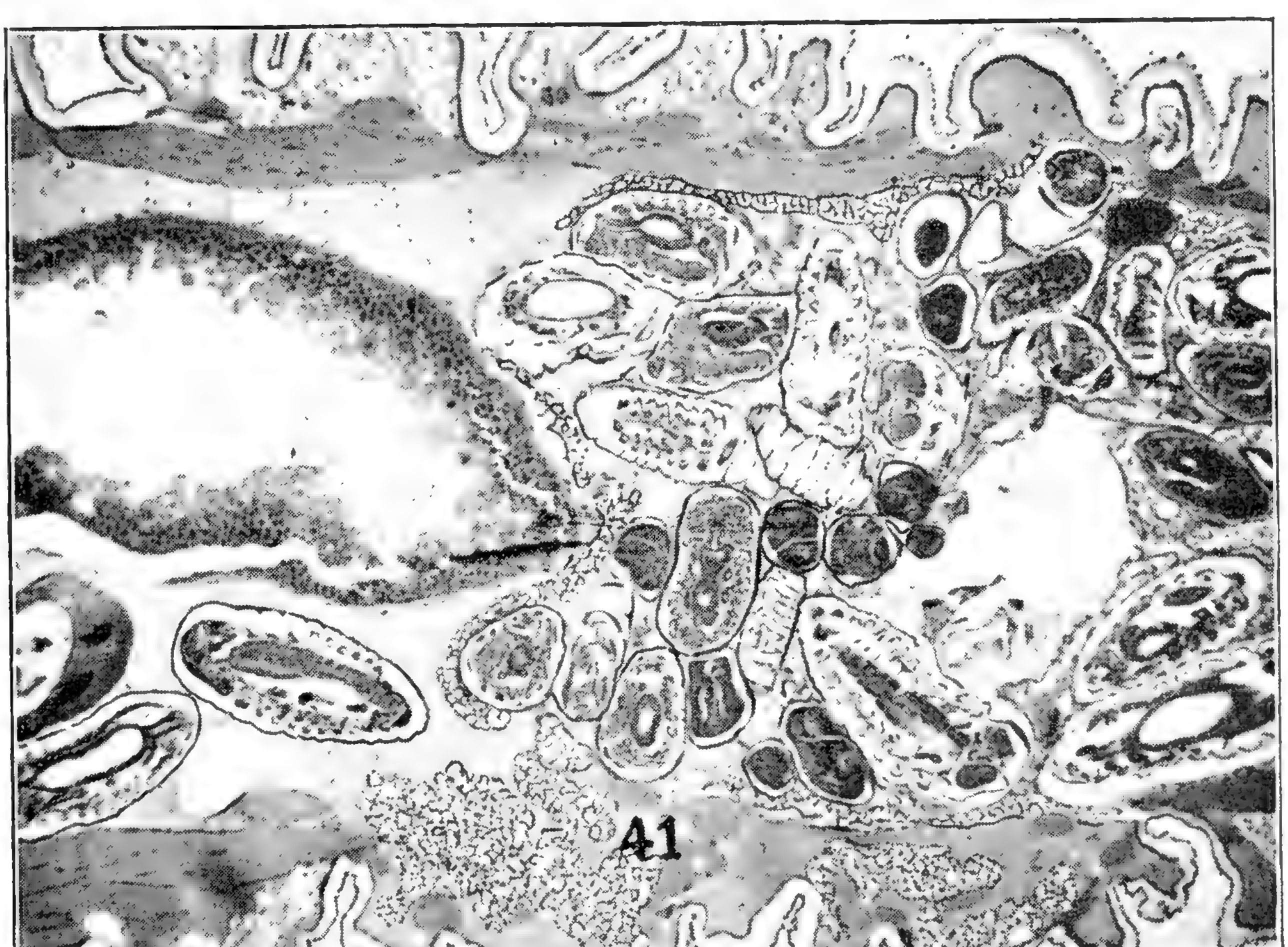
43.



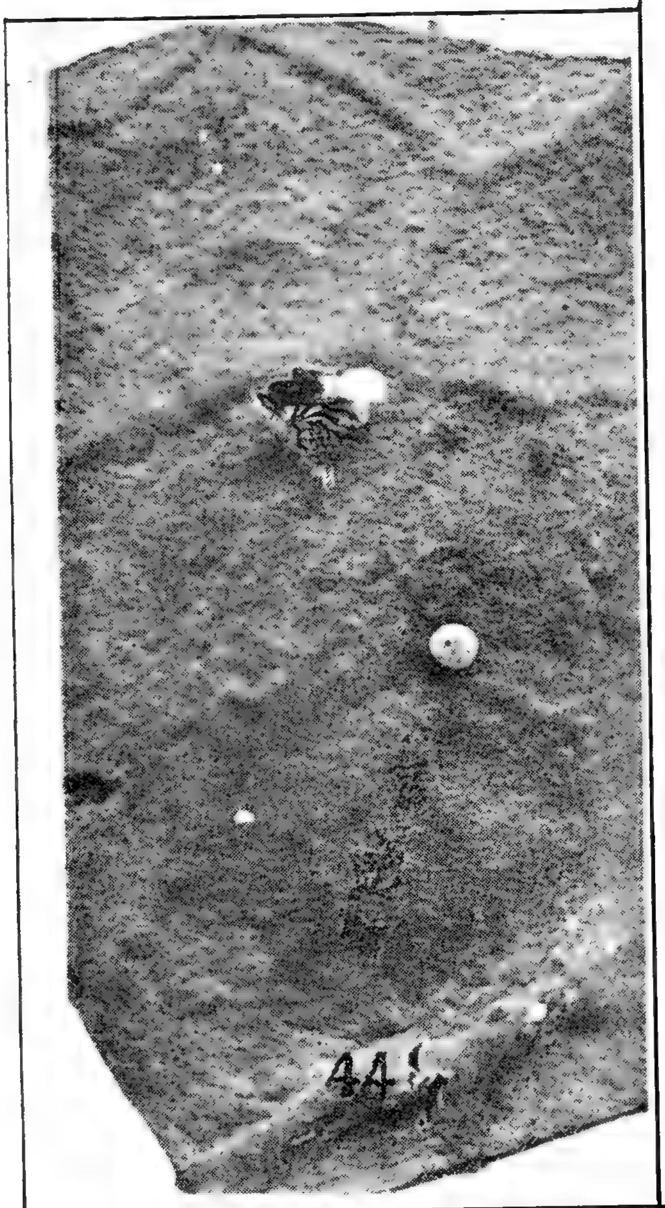
31

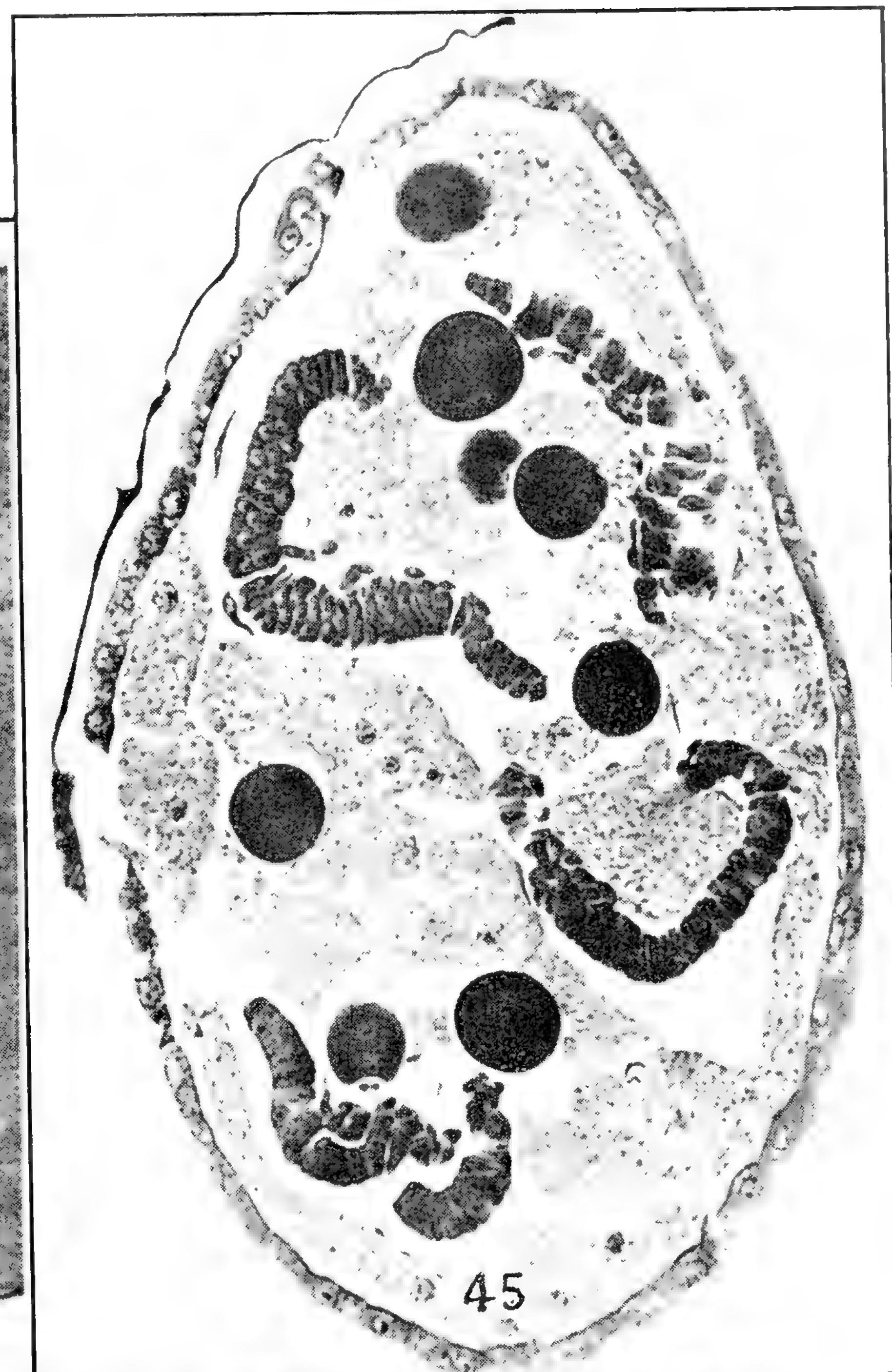
Leiby, Polyembryony in Insects.

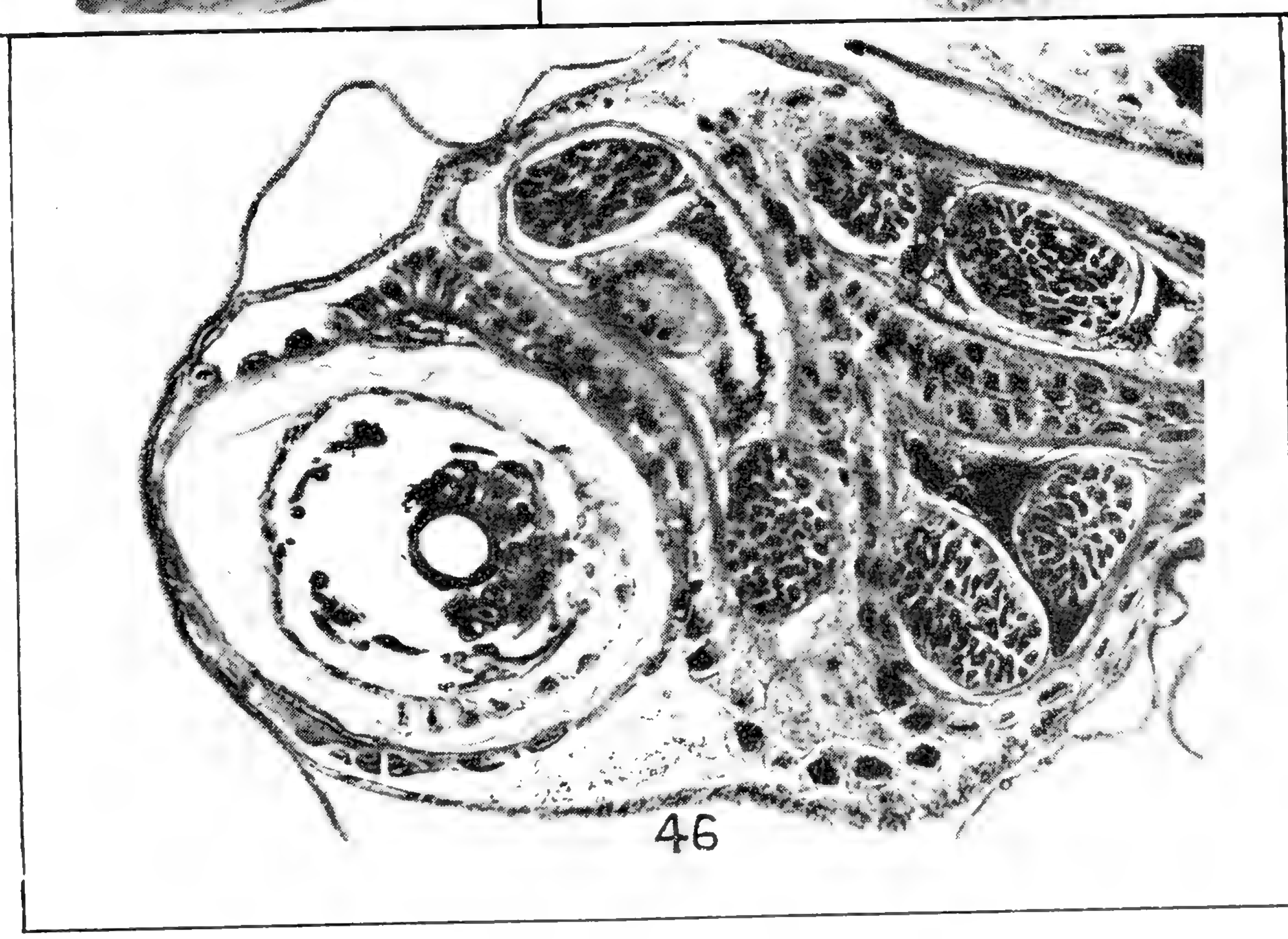




Leiby, Polyembryony in Insects.







Leiby, Polyembryony in Insects.

Fig. 39. Photomicrograph of a section through an entire parasite body in the morula stage. The morulas are about separated from each other structurally. All are still held together by the host fat body. Body wall of host is shown above a section through a sailvary at the left and the host intestine below. × 53.

Fig. 40. Section through a polyembryonal mass showing one embryo in its cavity with the thinned trophamnion surrounding it. Note the detail of the interembryonal matrix of host tissues. Portions of other embryos show above. × 168.

Fig. 41. Section through a polyembryonal mass in which the primary larvae are being set free into the cavity of the well grown host larva. The darker stained embryos are not as yet completely developed, — a few of them will fail to complete their development and are known as pseudembryos. × 43.

Fig. 42. Transverse section through a host larva showing sections of young parasite larvae grouped about the intestine. × 20.

Fig. 43. Longitudinal section through a host larva showing larval parasites within. × 18.

Copidosoma truncatellum.

Fig. 44. Parasite ovipositing in a host egg. Enlarged about ten times.

Fig. 45. Photomicrograph of a section through a host egg showing parts of eight parasite eggs deposited by several females. × 200.

Copidosoma thompsoni.

Fig. 46. Section through a protuberance of a host larva. The sexual embryos in the morula stage are shown in their cavities surrounded by the trophamnion and host tissues. On the left is a transverse section through an asexual larva. × 225.

Bref Aperçu sur la Présente Organisation des Services d'Entomologie Agricole en France.

Dr. Bernard Trouvelot, Entomologiste à l'Institut des Recherches Agronomiques, Paris-Versailles, France.

Les études sur les Insectes considérés dans leurs rapports avec l'Agriculture ont vu s'effectuer de profonds changements en France en ces vingt dernières années. Un bref résumé des étapes franchies s'impose au moment où l'impulsion donnée est appelée à se développer rapidement; il servira en même temps de guide aux Entomologistes étrangers, que nous souhaitons voir chaque année plus nombreux en voyages d'études dans notre Pays.

Etapes de développement. — Les premières études d'Entomologie agricole fondées sur des bases scientifiques apparaissent en France dès le XVIII[e] siècle. Certains Naturalistes*) et divers Agronomes éclairés **), ayant noté le rôle bienfaisant en agriculture d'insectes parasites ou prédateurs, songeaient à l'apport de ces Insectes dans les champs et les vergers ravagés par les chenilles; en d'autres circonstances ils conseillaient l'aspersion des chenilles et des pucerons, avec certaines décoctions végétales aux propriétés insecticides reconnues. Toutefois, il faut attendre le deuxième quart du XIX[e] siècle pour voir des études approfondies apparaître; elles se rapportent surtout aux insectes de la Vigne, des grains, des arbres fruitiers et des plantes de jardins.***)

L'invasion phylloxérique provoque un changement important. En effet, brusquement en 1864, se pose le dilemme brutal: combattre efficacement et sans délais un Insecte: le Phylloxéra, ou voir une culture des plus importantes, la Vigne, disparaître. Pareille acuité économique était d'ordre nouveau. En toute hâte, une mobilisation des énergies fut effectuée: Professeurs de Zoologie, Chimistes, Botanistes, quittèrent pour un temps leurs études principales et s'attaquèrent au problème posé. Avec la collaboration d'Agronomes ils précisèrent en dix ans de recherches les moyens de sauver la Vigne†).

---

*) Le plus célèbre fut Réaumur (1683—1757).

**) Leurs écrits se trouvent, en général, dans les Bulletins des Sociétés d'Agriculture, nombreuses à cette époque.

***) Parmi les pricipaux auteurs, il faut citer: Audouin, Decaux et Doyère.

†) Dans la liste des noms les plus célèbres se placent pour la Zoologie: Balbiani, Planchon, Lichtenstein, Valéry Mayet; pour la Botanique: Millardet, Viala. Il ne faut pas oublier le nom de l'Agronome G. Bazille auquel est dû l'idée si féconde du greffage, et la poursuite des tous premiers essais en ce sens.

L'invasion phylloxérique reste un des tristes exemples des sommes prodigieuses d'energie et d'argent que peuvent coûter des essais empiriques entrepris à la hâte. L'idée simpliste d'amener la précision des remèdes contre le Phylloxéra par la simple création d'un prix en argent de valeur élevée provoqua un indescriptible flot de recherches sans bases, sans méthode, sans résultats (voir les écrits particulièrement édifiant de Planchon et de Valéry Mayet sur le sujet), et peutêtre le spectacle chaotique alors offert ne fut-il pas sans influence sur le développement rapide de services spéciaux et permanents d'Entomologie agricole observés peu après en divers pays, en particulier aux Etats-Unis d'Amérique.

Vers la même époque arriva en France l'écho de l'invasion doryphorique traversant l'Amérique du Nord, puis la nouvelle des vergers Californiens ravagés par le Pou de San-José. Une sévère législation phytopathologique concernant l'introduction des végétaux vivants fut mise en vigueur sans délais.

Mais l'alerte phylloxérique (1865—1885) passée et la crainte de nouvelles introductions s'étant atténuées, le seul progrès résultant de la crise traversée ne se traduisit, en ce qui concerne le développement de l'Entomologie Agricole en France, que par une plus grande part donnée à l'étude des Insectes dans les enseignements de la Zoologie Agricole. Pouvant consacrer tout son temps à ces études, Valéry Mayet, sut, entre autre, développer un important cours faisant date à l'Ecole d'Agriculture de Montpellier.*) Timidement le Département de la Seine-Inférieure tenta un essai de laboratoire d'Entomologie Agricole;**) le Ministère de l'Agriculture publia des ouvrages de Brocchi et de M. Lecaillon sur les Insectes, ouvrages constituant surtout des listes des principales espèces rencontrées.***)

Une troisième phase dans le développement de l'Entomologie Agricole devait prendre place en 1896 avec la création, sous l'impulsion du Pathologiste et Agronome Prillieux, de la Station Entomologique de Paris. premier laboratoire d'état officiellement chargé de recherches sur les insectes nuisibles aux plantes cultivées. La direction en fut remise au Dr. Brocchi, puis un peu après à M. Marchal, Professeur à l'Institut National Agronomique, déjà connu pour ses travaux sur les insectes entomophages.†) M. Marchal la dirige encore aujourd'hui.

L'institution n'était pas suffisamment dotée pour vivre autonome; elle avait à prendre abri à l'Institut Agronomique. Néanmoins, son établissement eut une influence décisive: elle créait le premier noyau autour duquel se groupaient les énergies et se constituaient les cadres.††)

Dans les années qui suivirent, Gruvel, Professeur de Zoologie, fonda à Bordeaux (1904) la Société d'étude et de vulgarisation de la Zoologie agricole, Société qui fit paraître une publication nouvelle, la "Revue de Zoologie Agricole". Un embryon de Service phytopathologique vit le jour en 1910. En 1911, cinq laboratoires nouveaux furent créés pour l'étude de la Cochylis et de l'Eudémis dans les vignobles, comme suite à une très violente pullulation de ces insectes en 1910.†††) Leur

---

*) Valéry Mayet: Les Insectes de la Vigne, Paris 1890.

**) Ça et là à même époque, des tentatives de création de postes d'Entomologistes auprès d'Associations Agricoles prirent jour. Danyz occupa ainsi un poste à la Bourse aux grains de Paris. Les faibles ressources allouées ne leur permirent jamais un développement considérable.

***) A. Lecaillon. — Insectes et autres invertébrés nuisibles aux plantes cultivées et aux animaux domestiques Paris 1903.

†) En particulier, à cette époque, M. Marchal venair d'effectuer les premières observations conduisant à la curieuse découverte de la Polyembryonie chez les insectes.

††) M. Marchal continua à publier à cette époque ses nombreuses observations sur la biologie des Insectes entomophages. Au point de vue de l'organisation des travaux nous occupant plus particulièrement ici, une mention spéciale doit être faite de son étude „L'Utilisation des Insectes auxiliaires en Agriculture" (Ann. Inst. Agro. 1905, publiée en 1907).

†††) P. Marchal. — Compte-rendus des travaux effectués sur la Cochylis et l'Eudémis en 1911 (Paris 1912).

champ de recherches ne tarda pas à s'élargir et vu le nombre croissant des contributions qu'ils apportaient chaque année un périodique nouveau: „Les Annales des Epiphyties" fut fondé au Ministère de l'Agriculture pour leur publication (1912). La première acclimatation d'insecte auxiliaire étranger prit place à la même époque avec l'introduction, couronnée de succès, du *Novius cardinalis* (1911).

A quelques détails près, les éléments ainsi apportés constituent les bases principales de l'organisation des services d'Entomologie Agricole en France.

L'enseignement de l'Entomologie Agricole. — Lié au cadre ancien, qui est encore celui de tout l'enseignement de l'Agriculture en France, l'enseignement de l'Entomologie Agricole n'a pu suivre depuis de longues années le mouvement des recherches. Il ne fait pas l'objet de chaires spéciales dans les institutions d'éducation, et se trouve toujours incorporé aux cours de Zoologie prévus pour l'Institut Agronomique de Paris (P. Marchal, Professeur), diverses Ecoles d'Agriculture, l'Ecole d'Horticulture de Versailles (MM. Trouvelot & Willaume, Professeurs) et l'Ecole des Eaux et Forêts de Nancy (M. Hubault, Professeur).

C'est, certes à l'heure actuelle à Paris, grâce à l'activité du Professeur Marchal et vu le caractère avant tout scientifique de l'Institut Agronomique, que cet enseignement reçoit le développement le plus complet, bien que le nombre des leçons accordées soit des plus limité et que le rang de chaire fondamentale n'ait pu lui être dévolu.*)

Mais c'est là une situation que l'on peut considérer comme temporaire, un mouvement pour une réorganisation profonde de l'enseignement de l'Agriculture se dessinant depuis plusieures années déjà.

Un cours se rapportant aux insectes des cultures coloniales est donné par M. P. Vayssière à l'Institut d'Agronomie Coloniale de Nogent **). Le même Entomologiste professe à l'Ecole de Meunerie créée récement à Paris, cette dernière ayant mis à son programme les études sur les insectes des céréales et des farines.

L'Institut Agricole de Toulouse demande, chaque années, à M. Lecaillon, Professeur à la Faculté des Scienes de cette ville, des leçons de Zologie Agricole et l'Université de Rennes donne un cours isolé dans le même sens.

Les recherches. — Les principaux centres de recherches se trouvent à l'heure actuelle constitués par les laboratoires entretenus par le Ministère de l'Agriculture et dépendant d'un vaste organisme: l'Institut des Recherches Agronomiques. Les détails de la présente organisation datent de 1920, époque à laquelle un regroupement d'éléments anciens épars et l'élargissement des cadres furent effectués.***)

---

*) Il existe à l'Institut Agronomique de Paris deux sortes de cours, les uns payés à l'année attachent le Professeur à l'établissement, ils correspondent aux chaires fondamentales; les autres payés à la vacation sont faits par les Professeurs, dont ils ne peuvent constituer l'occupation principale.

**) Un service de documentation sur les Insectes nuisibles rencontrés aux Colonies Françaises existe depuis peu à Paris; M. Vayssiere en a également la charge.

***) P. Marchal: Rapports Phytopathologiques; Annales des Epiphyties, tomes 8, 9 et 10, Paris 1921—1923.

La vulgarisation des résultats acquis, l'inspection sanitaire des cultures, les recherches sur les mesures législatives à apporter ou la mise en oeuvre des traitements dans la pratique courante, font partie de services travaillant en harmonie avec l'Institut des Recherches Agronomiques, mais de personnel séparé.

L'Institut des Recherches Agronomiques comprend actuellement six laboratoires d'Entomologie Agricole, ou Stations Entomologiques, distribués dans les principales régions agricoles de la France *). Le plus important, situé à Paris, est dirigé par M. P. Marchal qui a également dans ses attributions la répartition des travaux parmi les Stations et la coordination des efforts entre celles-ci. Au laboratoire de Paris revient non seulement les problèmes locaux se rapportant aux régions du Centre et du Nord de la France, mais encore les problèmes d'intérêt national, diverses recherches de longue haleine qu'il peut conduire à bien, grâce à une installation plus vaste et à la possibilité de création, le cas échéant, de substations temporaires. Ainsi une annexe a travaillé longtemps à Menton (Alpes Maritimes) les problèmes d'acclimatation de divers Insectes auxiliaires et l'étude de la Mouche des Olives.

A partir du présent été, la Station Entomologique de Paris disposera d'un important laboratoire entouré de champs d'expérience, au Centre Agronomique de Versailles, c'est-à-dire aux abords même de la capitale, près de l'Arboretum du Museum d'Histoire Naturelle et des vergers de l'Ecole d'Horticulture. La réalisation de ce laboratoire montre que nous suivons la tendance récente, retrouvée en divers autres pays, qui consiste à permettre aux chercheurs biologistes de vivre presque constamment sur le champ d'expérience et de se trouver en même temps peu éloignés d'une grande ville.

Des laboratoires de Chimie, de Pathologie végétale, de Physique Agricole et d'Amélioration des plantes, situés sur le même emplacement à Versailles permettent une collaboration précieuse pour les études embrassant plusieurs Sciences Agronomiques.

Le centre de recherches présente des serres chaudes et des serres réfrigérées équipées pour les expériences délicates ainsi qu'un matérial d'élévage important destiné aux études des insectes en pleins champs et aux expériences sur les insecticides.

Parmi les principales recherches réalisées au laboratoire de Paris et en son annexe de Menton, il faut citer une longue série d'études sur les Insectes entomophages, avec introduction de diverses espèces étrangères (successivement *Novius cardinalis, Cryptolaemus montrouzieri, Aphelinus mali, Opius concolor, Habrobracon johannseni;* les trois premières sont maintenant définitivement établies). Viennent ensuite des études biologiques sur les insectes nuisibles les plus courants et la précision des mesures de contrôle à leur appliquer. Les ennemis des arbres fruitiers, de la Vigne, des plantes de cultures potagères, les Acridiens, les Insectes souterrains, retiennent tout spécialement l'attention. Récemment une série de recherches physiologiques sur le mode d'action des insecticides a été entreprise.

*) A signaler que parallèlement aux services entomologiques fonctionne à l'Institut des Recherches Agronomiques un laboratoire de recherches sur les Vertébrés utiles et nuisibles.

Diverses contributions systématiques se rapportant à des groupes particulièrement nuisibles (Coccides entre autres) ont également été apportées.

Le côte économique du contrôle des insectes a été étudié avec soin en ces dernières années. Des recherches similaires ont porté sur l'organisation d'Associations agricoles de lutte contre les ravageurs des cultures*), la législation des produits insecticides**), l'ensemble constituant un important chapitre sans le travail duquel le contrôle des insectes serait économiquement irréalisable ou ne donnerait que de faibles résultats.

La Station Entomologique de Rouen***) a étudié plus spécialement les Insectes du Pommier à cidre, des Peupliers, et des plantes de grande culture et pris temporairement une part importante à la précision des méthodes de lutte contre les Campagnols. Le laboratoire est dirigé par M. Regnier qui occupe les mêmes fonctions au Muséum de Rouen et qui est aussi connu pour sa contribution à l'étude de l'enseignement de l'Entomologie Agricole par les Musées.

L'Entomologiste Feytaud à la Station de Bordeaux a longuement étudié les insectes de la Vigne, du Pin Maritime et porte maintenant ses efforts sur le problème doryphorique.

Le laboratoire de Saint-Genis-Laval, près de Lyon, dirigé par M. Paillot, a dans ses attributions les recherches sur les Insectes des arbres fruitiers dans la vallée du Rhône et a choisi conjointement une spécialisation importante: l'étude des Maladies microbiennes des Insectes (Vers à soie, Abeilles, Insectes nuisibles).

A Montargis, près de Paris, M. Gaumont étudie surtout les Aphides.

L'Insectarium de Menton vient d'être transféré à Antibes et M. Poutiers qui en a la charge y continue les recherches sur les Insectes de l'Olivier, des Agrumes, ainsi que la propagation de divers Insectes utiles d'origine étrangère.

Le cadre des Stations Entomologiques a compris longtemps un laboratoire à Montpellier qui fut dirigé par l'Entomologiste Picard, mais qui est fermée temporairement.

Enfin, une Station sericicole vient d'être achevée à Alais (Gard)†) et un laboratoire d'Apiculture est prévu.

Ainsi constitués, les services de recherches du Ministère de l'Agriculture comprennent treize Entomologistes et un certain nombre d'Assistants techniques. La tendance actuelle est plutôt à la suppression des chercheurs isolés, et à leur groupement en des laboratoires moins nombreux, mais mieux équipés.

Les laboratoires sont établis sur des bases quasi permanentes. Leur but est l'étude des insectes principaux d'une région plutôt que celle d'un seul

---

*) Une Ligue s'est fondée en 1927 à Paris pour propager la défense rationnelle des cultures contre les ravageurs ou les maladies. Ses réunions mensuelles assemblent des membres de laboratoires, des Inspecteurs du Service de la défense des cultures, des membres de divers services d'Etat et des agriculteurs ou chefs d'Associations Agricoles.

**) La législation actuelle consiste principalement en une sévère règlementation de l'emploi des produits arsenicaux (1916), produits qui pendant longtemps demeurèrent interdits. Une loi sur la falsification des produits insecticides et les annonces trompeuses est en préparation.

***) Ce laboratoire est en partie entretenu par le département de Seine Inférieure.

†) Longtemps située à Montpellier et dirigé alors par Mozziconacci.

problème dont l'achèvement entrainerait leur suppression. Ce caractère est en rapport avec la nature trés variée des cultures qui se trouvent dans toutes lès régions françaises.*)

La Service de la Défense des Cultures. — Un tel service est le complément naturel de ceux de l'Institut des recherches; il étudie la vulgarisation dans les campagnes des techniques préparées par les laboratoires; les Services d'Avertissements et d'Inspection Sanitaire des cultures; la publication de tracts et la réalisation de conférences lui reviennent également.

En particulier, les mises au point pour les conditions locales d'application des méthodes générales de contrôle, et l'étude de „l'économie des traitements" pour les différents types d'agriculture sont du ressort du Service de la Défense des cultures.

L'inspection des végétaux à l'importation et à l'exportation rentre aussi dans ses attributions.

A signaler aussi un „Comité consultatif des Epiphyties" qui, réunissant les Chefs de nombreux services du Ministère de l'Agriculture et les personnalités scientifiques les plus connues, est appelé de temps à autre à donner des avis au Ministre sur les questions phytopathologiques à l'ordre du jour.

Autres laboratoires. — Certains laboratoires en dehors de ceux signalés précédemment fournissent occasionnellement des travaux d'Entomologie agricole. Une place à l'Institut Pasteur est occupée par l'Entomologiste Roubaud auquel sont dues d'intéressantes contributions. L'Institut Agricole de Toulouse possède depuis peu une installation pour l'étude des insectes dans la vallée de la Garonne (cette installation est dirigée par M. Lecaillon); le Musée de Strasbourg entretient un laboratoire dans le même sens (M. Burr, Directeur).

Certaines contributions viennent aussi d'Entomologistes privés; elles dénotent combien l'intérêt suscité par cette science se développe chaque année parmi le public.

Sociétés et Publications d'Entomologie Agricole. — La principale est la Société de Pathologie Végétale et d'Entomologie agricole de France, qui, fondée il y a quinze ans, comprend déjà 400 membres. Comme son nom l'indique, elle est aussi suivie par les Phytopathologistes. Des réunions mensuelles se tiennent à Paris et un bulletin est publié trimestriellement ne contenant que des contributions courtes, mais par cela même très variées.

De caractère plus local, mais atteignant un grand développement, se place la Société d'Etude et de Vulgarisation de la Zoologie Agricole, qui siège à Bordeaux et dirige une Revue de Zoologie Agricole et Appliquée.

---

*) Se reporter pour l'étude détaillée des recherches effectuées dans chaque laboratoire aux mémoires publiés dans les „Annales des Epiphyties". La même revue contient sous la rubrique „Rapports sommaires des Stations" un résumé des travaux réalisés année par année.

Le principal périodique est les „Annales des Epiphyties" publié par le Ministère de l'Agriculture et ouvert à tous les mémoires scientifiques importants. Il compte annuellement une moyenne de 500 pages.

Des tracts et des mises au point de vulgarisation existent sur les Insectes principaux, mais ne font pas partie jusqu'à ce jour de séries homogènes.

Avenir de l'Entomologie Agricole en France. — Certaines opinions très répandues ont tendance à faire croire que les pays d'agriculture ancienne, comme ceux de l'Europe, en particulier, sont beaucoup moins favorables à l'étude et au développement de l'Entomologie Agricole que les pays neufs, les appels à faire à cette science par l'agriculture étant supposés moindres pour eux. Il y a là une opinion erronée.

Dans les pays de vieille civilisation de nombreux insectes effectivement nuisibles sont ignorés parce qu'une tradition séculaire nous a accoutumé à vivre tant bien que mal avec eux. Nous les supportons en les tenant en échec par des moyens primitifs et empiriques; ces moyens depuis longtemps incorporés dans de vieilles et obscures routines sont susceptibles aujourd'hui d'améliorations considérables pour peu que leur étude scientifique soit entreprise.

L'orientation actuelle de notre agriculture ne doit pas être de cultiver plus de terre, mais d'obtenir de meilleures rendements; à ce point de vue le contrôle plus rationnel d'une multitude d'Insectes, jamais très abondants mais répandus partout, se place au premier rang.

Pour les pays neufs, le problème est d'un ordre tout différent. Ces pays sont le théâtre de grandes pullulations brusques revêtant la forme d'invasions calamiteuses et qui constituent les premières et si curieuses réactions du milieu biologique aux interventions de l'homme; mais elles ne forment qu'un des chapitres de l'Entomologie Agricole.

Durant les tâtonnements qui présidèrent à la création de notre carte actuelle des cultures en Europe, on ne persista pas dans l'introduction de plantes de grande valeur en certaines régions, seulement en raison des trop grands dégâts (souvent non identifiés) commis par les Insectes *). Il nous suffirait de quelques progrès dans les techniques de contrôle des Insectes pour reprendre avec de nombreux succès ces essais abandonnés depuis longtemps.

Dans les pays neufs au contraire, beaucoup d'essais comparables étant récents, la vraie cause des échecs observés est mieux connue; comme d'autre part en ces emplacements aucune tradition n'est venue mettre d'autres cultures il est naturel que l'on persiste dans les essais jusqu'à issue favorable. Ainsi le nombre des insectes classés parmi les nuisibles est-il considerable **).

En conclusion, les différences effectives que l'on observe entre les continents et qui furent le point de départ de l'opinion relevée plus haut,

---

*) Parmi les exemples les plus caractéristiques et pourtant très peu connus, se place la non-culture de la Betterave sucrière dans de nombreuses terres irriguées très fertiles du Midi de la France, terres actuellement occupées par des cultures moins riches.

**) L'histoire de l'introduction de la Betterave sucrière dans les plaines du Far West Nord Americain est un des meilleurs exemples que nous puissions citer.

résident dans l'aspect des problèmes posés et non dans l'importance de ces problèmes.

Il est à remarquer que ces différences vont d'ailleurs en s'atténuant très vite et nombreux sont déjà les problèmes revêtant, à très peu de chose près, le même aspect en tous les pays.*)

Considérée maintenant du point de vue purement biologique, l'Entomologie Agricole dans les pays d'Europe offre certains champs d'investigation de rare valeur. Pays surtout à culture intensive, ils présentent la balance des espèces la plus modifiée par l'Homme, et c'est dans de telles conditions que les forces jouant pour rétablir l'équilibre primitif actuellement rompu, atteignent leur maximum d'intensité. Peu de places sont, à notre avis, meilleures pour saisir dans leur essence les réactions internes des complexes biologiques.

Une plus complète prise en considération des problèmes aux données si nombreuses qui sont prédominents pour l'Europe, semble entraîner certains élargissements progressifs des bases utilisées pour les travaux dits d'Entomologie Agricole. Physiologie et Ecologie joueront à ce qu'il semble un rôle sans cesse plus grand; d'autre part, la notion du contrôle formant plus un tout avec les études qu'une suite d'essais empiriques juxtaposée à l'étude biologique des espèces, apparait de plus en plus. Les appels aux sciences expérimentales (Physique, Chimie entre autres) éloignées de d'Entomologie proprement dite, vont en croissant. Ce mouvement, suite logique des découvertes internationales de ces trente dernières années commence à fixer sa voie en France, et l'on peut déjà dire qu'il se trouve en parfaite harmonie avec différents développements de même nature observés, ces dernières années, en de nombreux autres pays.**)

Conclusions. — Le développement de l'Entomologie Agricole présente en France trois grandes étapes jalonnées par la crise phylloxérique (1864), puis par la création du premier service permanent de recherches (1896).

Sauf, toutefois, en ce qui concerne le cadre réservé à son enseignement et malgré les grosses difficultés traversées par notre pays, cette science fut l'objet d'importants développements en ces quinze dernières années: le nombre des travailleurs a considérablement augmenté, des installations nouvelles sont apparues, des périodiques ont vu le jour et les bases d'organisations importantes ont été jetées. Un mouvement semblable s'observe dans les recherches d'Entomologie médicale et d'Entomologie générale. Deux services officiels se partagent surtout le travail. L'un effectue les recherches fondamentales et constitue avec ses six laboratoires une section de l'Institut des Recherches Agronomiques.

L'autre, le Service de la Défense des Cultures, s'occupe des questions législatives, étudie la mise en application dans les campagnes des techniques préparées par les laboratoires, conseille les agriculteurs et exerce une inspection sur le trafic des végétaux.

---

*) L'un des plus anciens était certainement celui des Insectes transportés de continent à continent.

**) Un court aperçu de la question fut donné par M. Willaume dans sa récente note: La Médecine des cultures commerciales (R. d'Histoire Naturelle appliquée, Vol. VIII, No. 12, Paris, 1927).

Pour les laboratoires, malgré des liens étroits qui continuent à les unir entre eux, une certaine décentralisation s'effectue, laissant prendre à chacun un véritable caractère régional. Pareillement se poursuit une concentration des chercheurs en des centres de travail moins nombreux et par cela même mieux outillés. Ces laboratoires sont permanents et étudient plutôt les problèmes d'une région qu'un Insecte particulier.

Pour l'avenir, nous voyons le mouvement actuel appelé à se développer. Il sera poussé non seulement par des nécessités économiques chaque jour plus clairement discernées, mais aussi par l'incomparable valeur scientifique des champs cultivés en ce qui concerne l'étude des forces internes gouvernant tout complexe biologique.

Preliminary Report on the Citrus Scale-Insects of China.

Professor F. Silvestri, Portici, Italy.

China or at least the South-Eastern portion of Asia is considered the original home of the species of Citrus; therefore that country has a very particular importance for the study of insects infesting Citrus. I owe to Professor Harry Smith, to whom I express here my best thanks, the opportunity of visiting China and adjacent countries, such as Indochina, Philippine Is. and Japan, during one year and one half for the purpose of searching for parasites of some Citrus scales. Therefore I had occasion to pay special attention to the scale-insects of Citrus in general, and I am able to give some information about them.

The provinces of China where I visited more or less extensive Citrus orchards and inspected Citrus trees scattered in gardens and also a few wild ones on the mountains, were: Yunnan, Kwangtung (the British possession Hongkong and Kowloon included), Fukien, Honam, Changsha, Kiangsi, Pechili. Therefore it may be assumed that my report will not receive many additions from a study of the Citrus scales in other provinces where there is extensive cultivation of Citrus, as in Kwangsi, Szetchouen.

The species of scales seen by me (the few specimens of 4 more are not yet named) were 29, of wich I give here some information as to their distribution and parasites. This number is the highest known as attacking Citrus trees in any region, but we must immediately note that no species is confined to China and that up to the present one species has been recorded only from China and Japan (*Prontaspis yanonensis* Kuw.), the others have been transported to other tropical or subtropical countries, where they are infesting Citrus and other plants.

Comparing the number of species of Citrus scales in China and in Europe, we note that about half the species have not yet reached Europe, and that in Europe *Aspidiotus hederae* is common, whereas it does not exist in China and may be considered a new pest of Citrus of Afro-mediterranean origin, as well as *Ceroplastes sinensis*, which is of African or of American origin.

The status of Citrus scales in China is such that artificial control is, generally speaking, not necessary in the open orchards, the scales being counteracted by natural factors of control. The species which sometimes do damage are: *Parlatoria zizyphus*, *Chrysomphalus aonidum*, *Chrys. dictyospermi* and *Aonidiella aurantii*.

Monophlebinae.

1. *Drosicha contrahens* Walk.

A few specimens of this species were collected in Yunnan in gardens of the town of Yunnanfu, on Lemons, a few near Canton on Tangerines and others on Pomelos near Foochow; at Ebolian, a village a few miles from Foochow, at the foot of Mt. Ausu, September 26, 1924, I saw several hundred specimens on a pomelo about 3 meters high. I placed a few specimens in alcohol and 36 alive in a glass-tube; these latter all moulted and 35 were still alive on December 23, and gave adults of *Cryptochaetum.*

All the specimens (15) I collected at Yunnanfu, February 25, 1925, were dead and had almost the whole ventral side occupied by a layer of about ten cocoons, 2 mm. long and 1 mm. broad, empty at that time; in one found an adult and in another an immature specimen of a Proctotrupid, which is not yet named. A specimen of *Drosicha*, with similar cocoons, was collected by me near Canton on January 1, 1925.

At Shanghai on May 19, 1925, I saw trees of *Fotinia* infested by *Dros. contrahens* and among the larva of the 3d instar I noticed numerous larvae of *Novius limbatus* Mots.

2. *Icerya aegyptiaca* Dougl.

I collected a few adult females of this species on Citrus at Hongkong on December 17, 1925, and at no other time had I occasion to see it on Citrus, but on other trees.

3. *Icerya jacobsoni* Green.

This species is rare on Citrus; I found only 3 specimens of it once at Hongkong, but in the same locality I collected it on leaves of a shrub (Dec. 17, 1924) and from these I got (January 20, 1925) 25 specimens of a species of *Proctotrupidae*, of wich 8 were males. As I collected the same *Icerya* on Guava in Honan (Canton) on January 3, I placed some specimens of the parasite in a tube with a leaf bearing specimens of *Icerya* and saw one female parasite oviposit through the dorsum of the scale. This reacted, bending its posterior part upward and forward and covering the body of the parasite for half a minute. I kept the parasitized specimens of *Icerya* in a glass-tube, but no parasites emerged.

4. *Icerya purchasi* Mask.

This species is not common in China and not a destructive pest, but has been found by me at Hongkong, Canton, Peikuan near Foochow, Changsha, Shanghai, therefore from South to Central China and from the coast to the interior. I saw it in numbers on a tree of Pomelo at Peikuan and on small trees in an orchard at Chapei near Shanghai. On a well infested Pomelo at Peikuan there were large colonies of *Polyrhachis dives* F. Smith, which afford great protection to *Icerya* against its enemies; but notwithstanding I collected on the same tree some specimens (larvae and adults) of *Rodolia.* I am convinced that *Icerya purchasi* is an old inhabitant of China and that there it is well controlled by *Rodolia* and other local natural factors, because no *Novius cardinalis* was seen by me, and I heard nothing of an introduction of this ladybird into China.

5. *Icerya seychellarum* Westw.

I saw a few specimens on Citrus in South China (Hongkong, Canton) and at Guik Su (Foochow) and also in Indochina (Van-Phu, Phuto), where I collected a predatory *Rodolia.*

Pseudococcinae.

6. *Pseudococcus citri* Risso.

A small number of this species was collected by me on Pomelo and on Tangerine near Foochow.

7. *Pseudococcus comstocki* Kuw.

This is the more common species of *Pseudococcus* on different species of Citrus throughout the various provinces of China from the South to the Centre and from the coast to the interior as far as Changsha, which country I visited.

I never saw the species abundant except one time at Peikuan near Foochow on a Pomelo closely situated near the one badly infested by *Icerya* and like it protected by strong colonies of *Polyrhachis dives.*

I got one species of *Chalcididae (Anagyrus),* one of *Proctotrypidae* and one of *Cecidomyidae* from specimens of this species, and saw preying on it species of *Scymnini* and larvae of *Cecidomyidae.*

8. *Pseudococcus filamentosus* Ckll.

This species was seen by me on Citrus in South China at Kowloon, San Vui (Kwangtung), Canton; but in each case not abundant and parasitized by *Anagyrus.* One or two species of *Scymnini* also prey on it. This species and its parasites were collected by me also in Formosa on Citrus and on Ficus.

Pseudococcus filamentosus was very injurious in the Hawaiian Is. until 1925, but Mr. Fullaway, with the help of the knowledge obtained by me in the East, succeded in collecting and importing the parasites.

Lecaniinae.

9. *Ceroplastes floridensis* Comst.

This species was collected on Citrus by me in a few specimens at Macao, Guik Su (Foochow), Wuchang and was found very abundant on Evonymus at Shanghai. I collected near Foochow some specimens on a Ficus tree and bred an Encyrtid not yet named. This species was never observed by me on Citrus in China in numbers to be considered as injurious.

10. *Ceroplastes rubens* Mask.

This scale exists in the whole Citrus belt of China, but I saw it very rarely in the Kwangtung and Fukien Provinces; it was quite numerous on some trees in a garden at Yunnanfu, rare in Chagsha, and abundant on some other trees than Citrus near Shanghai. I saw it very rarely in North Annam and in Tonkin; it is common and injurious in Japan. I bred an *Eusemion* from specimens of Hongkong and of Yunnanfu; but as the

species of this genus are known to be secondary parasites, there must be a primary parasite of *C. rubens* in the places mentioned. From what I saw during my trip, *C. rubens* is not a pest of Citrus in China.

11. *Ceroplastes ceriferus* (A n d.).

This is very widely distributed in China on many trees, but I found few specimens of it on Citrus, once in Fukien (Liu Giu) and another time at Changsha.

Near Shanghai I saw a big ornamental tree very much infested with this *Ceroplastes*, but I never saw a Citrus tree which was more than very sparsely infested and this perhaps accidentally.

I got from a specimen of Hankow, on branches of a bush, an *Eusemion* of the same species as that obtained from *C. rubens*.

12. *Saissetia oleae* (B e r n).

I only saw 3 specimens of this species on a small Citrus tree near Canton; in no other place did I see this scale on Citrus, but on *Erythrina indica;* I found specimens on this tree near Kowloon, Canton, Amoy and Swatow. In these localities I collected a few pieces of branches well infested with *Saissetia* and this heavily parasitized by *Anysis saissetiae* (A s h m.).

13. *Coccus hesperidum* (L.).

I found this species very rare on Citrus in Macao and other places of South China; once I found a few twigs near Foochow well infested, but the specimens were heavily parasitized by a *Coccophagus* and a *Microterys.*

14. *Coccus* sp.

I collected near Foochow and at Sanshachi (Changsha) another *Coccus*, which at first sight is similar to *C. hesperidum*, but judging from several microscopical characters seems to be distinct. This has not yet been well compared with all the known species and therefore cannot yet receive a name. Specimens with holes were seen in both localities. *Coccus longulus* (D o u g l.) is recorded on Citrus in China and also an unrecognizable *Coccus diacopeisa* A n d.

15. *Pulvinaria cellulosa* G r e e n.

This, I think, is the more widely distributed species of *Pulvinaria* on Citrus in China from the South to Changsha and Shanghai, but is seldom seen in numbers on the same tree, and if it forms small colonies, it is always very strongly parasitized by *Coccophagus* and *Microterys.*

There have been recorded for Citrus in South China (Canton) *Pulvinaria psidii* M a s k. and *P. polygonata* C k l l.

D i a s p i n a e.

16. *Aspidiotus lataniae* S i g n.

This species was seen by me on several trees in an orchard of Kowloon, covering the lower leaves of the small lower branches of a few Citrus, and near Canton, Foochow, Hankow in small numbers here and there on differ-

ent species of Citrus. It cannot be considered an injurious insect, judging at least from what I saw at the time of my visit.

I saw *Chilocorus* feeding on it, and obtained from it an *Aphelinus.*

17. *Pseudaonidia duplex* Ckll.

This species is not common on Citrus in South China from Canton to Foochow, but a few specimens were found here and there.

I bred from it an important *Aphelinus* and from a female from Foochow another Chalcid parasite, which is being studied.

18. *Morganella longispina* (Mask.).

I found specimens of this species on fruits of Tangerines near Canton (Jan. 1925), but in no other place did I notice the species on Citrus. I collected twigs of *Ficus carica* heavily infested with this species in a garden at Macao, from which I bred several specimens of a new species of *Archenomus.*

19. *Chrysomphalus aonidum* (L.).

This Coccid is present on different species of Citrus and on some other plants also (*Ficus, Aspidistra, Taonabo, Evonymus,* etc.) throughout the South and Central part of China, and I saw it in injurious numbers on some trees at Peità (Foochow) which grew on the shore of a small lagoon, and obtained a few here and there in the Citrus orchards of the neighbourhood of Foochow. It is in China certainly an insect fairly well controlled by natural factors among which I can indicate: *Comperiella bifasciata* How., *Casca smithi* sp. n., *Aphelinus chrysomphali* Mercet, *Chilocorus kuwanae* Silv. and *Telsimia emarginata* Chapin.

Casca smithi is, in my opinion, the more effective parasite of *Chrysomphalus aonidum* in the South as far as the 25° n. L., because I did not find parasitized specimens in the region of Foochow, but everywhere more South and also in Formosa and Luzon.

This parasite is endophagous and generally develops in the female of *Chrysomphalus* to the number of 4 to 6, exceptionally fewer or 7.

Aphelinus chrysomphali was a very abundant parasite of this *Chrysomphalus* near Foochow during the summer; *Comperiella* was bred in numbers from material of Shanghai as far as Changsha and of North China as far as Peking. The predaceous Coccinnellids do their share in the control of the scale.

20. *Chrysomphalus dictyospermi (Morg.).*

I found this species quite common along the Yangtse River in Wuchang, Hankow and at Changsha and near by (San-sha-si) on Citrus and on *Evonymus, Hedera, Fotinia,* but, strangely enough, I did not see it in the many other localities I visited for Citrus scales, viz. Fukien, Kwangtung, Yunnan, Shanghai, Peking, and Indochina, Luzon, Formosa and Japan. I knew that the species was present in the collection of the Canton College of Agriculture as collected near Canton, and I searched in South China and elsewhere outside the Yangtse provinces as much as I could, but I found it only along the Yangtse and in Changsha; I conclude from what I saw that *Chrysomphalus dictyospermi* probably is confined to Central China and has not gained a definitive hold in other parts of China. Therefore the question arises which is the original home of this coccid? Before my trip I

assumed, with other Coccidologists, that the original country probably was South America, but now I am more inclined to believe it to be Central China. I like to note that it is also worthy of consideration that *Chrys. dictyospermi* has not gained a foot-hold in Japan; at least I did not see it on the very many trees where I looked for it.

The parasites of this *Chrysomphalus* I bred or observed are: *Comperiella bifasciata, Aphelinus chrysomphali, Chilocorus kuwanae.*

These parasites, and especially *Comperiella,* work very well against *Chrys. dictyospermi;* I saw trees of Citrus and small plants of Evonymus in gardens at Changsha with the leaves having almost all the female scales killed by *Comperiella.*

21. *Aonidiella aurantii* Mask.

I found this species on Citrus and on many other trees in all the localities I visited from Indochina to Peking, and the Philippine Is., Formosa and Japan. For me it is certain that the original home of the species is the Far East, where it is generally well controlled by natural agencies, comprising several parasites I bred. Some of these are well-known, others belong to new species discovered by me: *Comperiella bifasciata, Casca* sp. n., Prospaltella *aurantii, Aspidiotiphagus* spec., *Aphelinus* spec., *Chilocorus kuwanae, Telsimia emarginata. Comperiella bifasciata* is the more general parasite, but at the time of my visit it was rare in China, abundant in some places of Japan, where I collected much material of Podocarpus infested with this scale parasitized by *Comperiella.*

It is interesting to record that I saw at Caibé (Indochina) a small tree of Citrus quite well infested on the branches with *Aonidiella* preyed on by a number of *Chilocorus nigritus.* The scale was found very rare on Citrus at Macao, in Hongkong and at Canton, but in a garden at Fati near Canton I saw a low Cycas well infested and another even more infested in the botanical gardens of Hongkong. From the specimens of Canton on Cycas I bred *Casca* sp. n., from that of Hongkong *Aphelinus* and saw preying on the same plant larvae and adults of *Telsimia emarginata* Chapin.

I found a Pomelo situated near a small lagoon at the foot of Kusang (Foochow), which was also well infested, and I bred *Comperiella* from these specimens. This parasite is the more general endophagous of *Aonidiella aurantii* throughout the East, but its work is not intense everywhere. So I saw on June 12 near Kasseda in Japan (Kiushiu) an infestation of Citrus by this scale, the larger portion of the specimens parasitized by *Comperiella;* the same day, at Nagayoshi village, I visited a terraced Citrus orchard at an elevation of about 100 meters, where a number of trees had the leaves and branches quite well infested with *Aonidiella,* of which not one I found parasitized by *Comperiella,* but only a few young specimens by *Aspidiotiphagus.* I like to note also that in a forest of Podocarpus nageae near the Nara's Park in Japan, I found little infestation by *Aonidiella aurantii* on small trees or low branches of big trees, and everywhere I found as a common and sole parasite a *Casca* (a new form I shall describe shortly). This *Casca* was present in the forest only, at least I did not see it on *Aonidiella* outside of the forest at the time of my visit in July and August, notwithstanding the presence of some *Aonidiella* on Podocarpus macrophylla.

What may be the reason of this peculiar distribution? The plant? I do not think so, because I saw other (few indeed) trees of Podocarpus nageae in other gardens of Japan, but I did not find the same *Casca*. It is probable that the presence of it in the forest is connected with shade and moisture, but other observations are necessary for gaining a better understanding of the question.

Prospaltella aurantii and *Aspidiotiphagus* were not very common at the time of my visit, but their action can sometimes be of some importance.

The principal predators I have seen at work on this scale were *Chilocorus kuwanae, Telsimia emarginata,* and the Thysanopteron *Aleurodothrips fasciapennis* Fakl., which is known as predaceous on white-fly in Florida. Unfortunately the activity of *Comperiella bifasciata* in the Far East is counteracted by *Marietta carnesi* (How.), which is sometimes quite common.

22. *Lepidosaphes pinnaeformis* (Bouché).
(= *Lepidosaphes citricola* Pack., *L. becki* Newm.).

This species was found by me on different species of Citrus in South China as far north as Foochow, but I did not see it along the Yangtse River, nor in Changsha and Shanghai.

I observed it in Indochina, on Luzon, and as very rare on Formosa.

Only small trees in nurseries and very low branches of small trees in orchards were sometimes found well infested by this scale, but in the open I never saw a bad infestation and more in the open I could find no specimens free on leaves or fruits, but only on rolled-in leaves or on leaves fastened together by spiders.

Throughout South China and other hot countries parasitic fungi play certainly an important part in the control of this and other scales, especially *Diaspinae*, but I think that some parasitic and predatory insects are of great use, these being *Casca chinensis* How., *Aphelinus* sp., *Aleurodothrips fasciapennis*, and Coccinellids: *Chilocorus* and others not yet determined.

23. *Lepidosaphes gloveri* (Pack.).

This species is present in China on Citrus from the more Southern parts to Peking. It is more common in Central than in South China and is very common in Japan. I bred from material obtained at several places specimens of *Prospaltella aurantii* How., and I think this is the more common and general parasite in the Far East.

The same predaceous beetles and the *Aleurodothrips* which attack *L. pinnaeformis* prey also on this species.

24. *Parlatoria zizyphus* (Lucas).

This scale is distributed throughout China where Citrus are cultivated in the open or in pots; I saw it everywhere from the South to Pekin and in Indochina, Formosa and Luzon.

It apparently is the more abundant scale on Citrus in China and in some places is quite abundant and injurious, but especially so on nursery stock and on too shady trees. It is the scale more commonly seen on fruits also, especially on Tangerines.

This scale suffers very commonly great mortality from fungi, which are very visible as small red patches on the body; throughout the provinces of China, as well as on Luzon and Formosa, *Aspidiotiphagus lounsburyi* (or a form of it) is its particular Chalcid parasite, which has been introduced in other, very distant, countries, such as Africa, where I saw it in Senegambia. The true importance of this parasite must be further studied, annual observations being necessary.

25. *Parlatoria pergandii* Comst.

This species is widely distributed on Citrus from the South to Peking. Trees situated in shaded places and nursery stock are sometimes somewhat infested, but generally speaking it is not an injurious species.

I bred one species of *Prospaltella (P. inquirenda* Silv.) and one of *Aphelinus*. The predaceous *Coccinellidae*, such as *Chilocorus* and *Telmisia*, also feed on this scale.

26. *Prontaspis citri* (Comst.).

I collected this species in South China: Hongkong, Kowloon, Canton and also in Tonkin, but I never saw it in great numbers. I found specimens with holes made by internal parasites more commonly in Coxan (North China), but I did not obtain specimens of the parasite.

27. *Prontaspis yanonensis* Kuw.

I first saw this species in the Citrus orchards near Foochow and I collected specimens on Citrus also at Changsha, Wuchang, Soochow. I found the trees lightly infested and never so badly as one may see them near Nagasaki. I bred an *Aphelinus* from females of Foochow and Changsha.

28. *Hemichionaspis aspidistrae* (Sign.).

I found this species on Citrus trees in many places from Canton to Hongkong and Foochow; especially in the last named locality was it found somewhat common, but not injurious. I saw some females with parasite holes, but I did not breed the parasite.

29. *Fiorinia theae* Green.

This species is very common in South China from the sea to Yunnanfu. In this latter locality I saw it more numerous than elsewhere. The species was rare in Fukien and I did not see it at Changsha, Hankow and Shanghai. I did not breed parasites from it. I found the species to be also common in Tonkin.

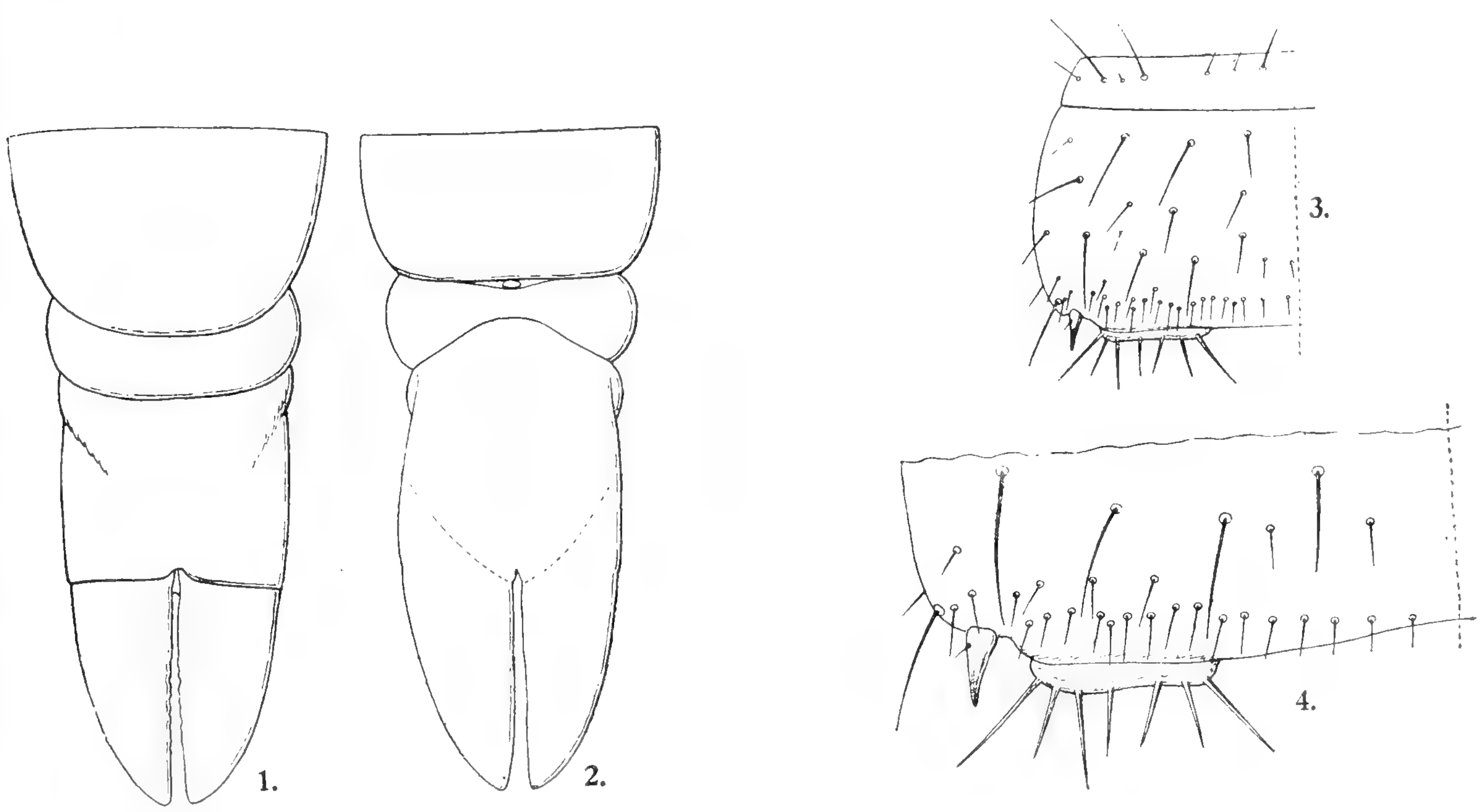
On Postembryonal Development of Japygidae (Thysanura).

Professor F. Silvestri, Portici, Italy.

(With 10 text-figures.)

There is still an author*) who maintains that *Projapygidae* are the first larval stage of *Japygidae*, notwithstanding that I have discussed this question and thought to have demonstrated the contrary when I described the first larva of *Japyx platensis* Silv.**).

To truncate any doubt on this question I can make the statement that I know the first larval stage of several *Japygidae* and that they are similar to the described first stage of *J. platensis* and to that of *Japyx nigerianus* Silv., of which I exhibit specimens. In describing the first and second larval stages I shall call attention to a few other points of the postembryonal development of *Japygidae*. I invite my collegues to inspect specimens of *Projapyx stilifer* O. F. Cook and compare them with specimens of the first and second larvae of *Japyx nigerianus* Silv.



Figs. 1—2, first instar of larva: 1. posterior part of the body from eighth segment (dorsally); 2. the same ventrally. Figs. 3—4, second instar: 3. half of first urosternum; 4. posterior part of the same urosternum more enlarged.

First instar of larva (text-figs. 1, 2). This is white, hairless, 3.50 mm long and 0.35 broad. The antennae are 36-jointed (ill jointed); the

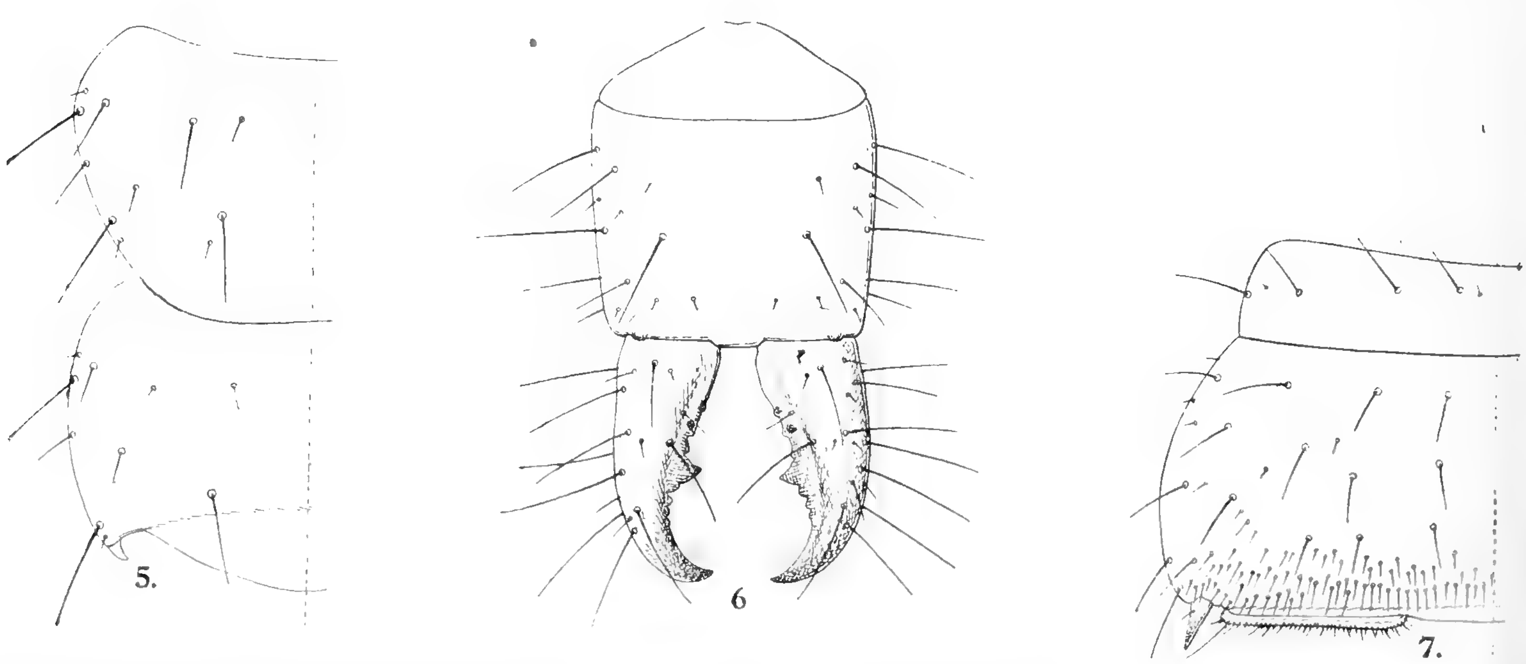
*) Verhoeff, Deutsche ent. Zeitschr. 1923, p. 33, etc.

**) Zoologischer Anzeiger XXVIII. (1905), pp. 638—641.

branches of the forceps are elongated, little longer than the tenth abdominal segment, their internal side straight, smooth or microscopically toothed, the outer side gradually attenuated, the extremity subacute. The seventh abdominal tergite has the posterior angles subrotundate. First admominal sternite provided along the posterior margin with a few very short setae. The stili are very short.

The first larva was found by me protected, as the eggs, in the middle of the arched body of the mother.

S e c o n d i n s t a r o f l a r v a (text-figs. 3—6) shows a great change from the first especially in the form of the forceps and a few other characters, but the number of joints of the antennae remains the same (36). Body 4 mm long and 0.40 broad. The branches of the forceps are arcuated as in the adult, and have an opposite strong submedian tooth, 2 superior and 3 inferior proximal small teeth and 3 small distal ones. The seventh abdominal tergite has the posterior angles produced in an acute short process; the first abdominal sternite has a subcoxal organ which is less broad than half the sternite and is provided with seven short setae; the sternal surface beyond the subcoxal organ has some very short setae alsmost aranged in a transverse row. The body has the typical setae of the genus.



Figs. 5—6, second instar of larva: 5. half of sixth and seventh urotergites; 6. tenth segwith forceps (dorsal view). Fig. 7, adult, half of first urosternum.

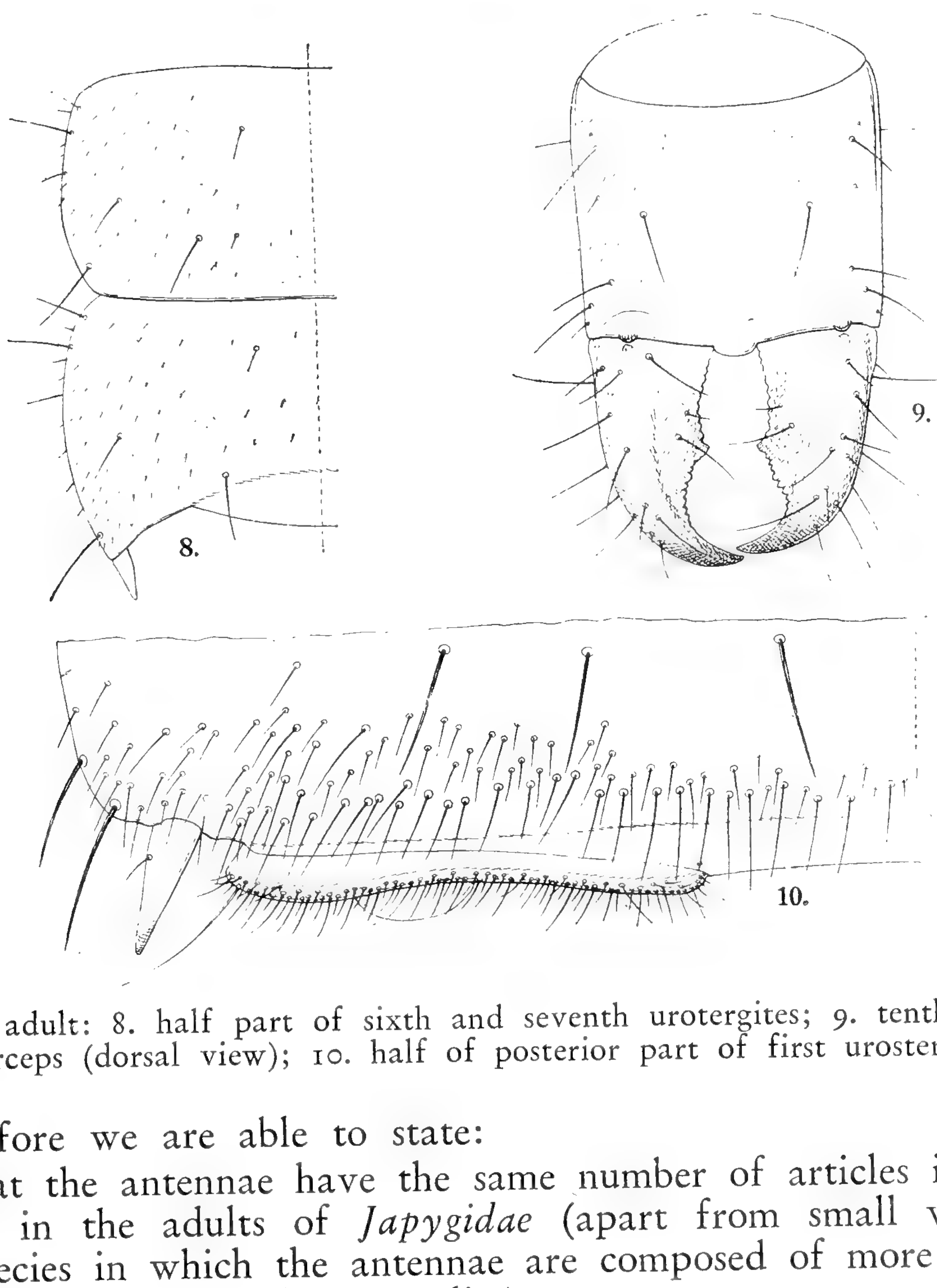
The second larva is, for a short time after the moult, protected by the mother like the first larva, but after that it becomes free.

A d u l t f e m a l e (text-figs. 7—10). Antennae generally of 36 articles, but this number varies a very little. Body up to 12 mm long and 1.60 mm broad (at 7th urotergite).

The seventh abdominal segment has the posterior angles strongly produced into an acute attenuated process; all the preceding segments have the posterior angles rounded. The first abdominal sternite has the subcoxal organ broad, about two-thirds of half the sternum, and is provided with two rows of short and shorter setae; the sternal surface beyond the subcoxal organ has many short setae distributed in two to five transverse irregular rows.

C o n c l u s i o n. — Comparing the first instar of the larva with the second instar the great change lies in the appearance of the setae on the body, in the posterior angles of the seventh abdominal tergite becoming acute, in the appearance of the subcoxal organ of the first segment, and especially in the branches of the forceps being in shape just like those of the adult. There is no increase in the number of articles of the antennae in this stage.

Comparing the second instar of the larva with the adult we see a stronger development of the posterior angle of the seventh urotergite, an enlargement of the subcoxal organ of the first urosternite and an enrichment of setae on the same, a stronger development of the branches of the forceps and an enrichment of their smaller teeth. The antennae can be considered composed of the same number of articles as in the larvae.



Figs. 8—10, adult: 8. half part of sixth and seventh urotergites; 9. tenth segment with forceps (dorsal view); 10. half of posterior part of first urosternum.

Therefore we are able to state:

a) that the antennae have the same number of articles in the larvae as in the adults of *Japygidae* (apart from small variability in species in which the antennae are composed of more than 30 articles, and possible anomalies);
b) that the forceps of the first stage of the known larvae has the branches unsegmented, untoothed and not arcuated;
c) that the angles of the seventh urotergite are round in the first larval stage, and that the posterior margin of this tergite increases from the second larval stage to the adult;

d) that the first unrosternite acquires broader and more hairy subcoxal organs and a more hairy posterior surface from the second larva to the adult.

Besides the second larval instar of *Japyx nigerianus*, I know this larval stage of *Japyx solifugus* Hb. and *J. major* Gr., and I can state that they have the same number of articles of the antennae as the adults.

When there are species of *Japyx*, which have, in the adult stage, several urotergites with the posterior angles produced, they, as I have said in the description of *J. akiyamae* Silv.*), acquire these characters from stage to stage; namely, the second stage has the posterior angle of the seventh segment produced, the third stage that of the sixth and fifth, and so on; but the antennae retain the same number of articles from the larval stage to the adult.

*) Boll. Labor. zool. Portici, XXII, pp. 58—62, figs. VII—IX.

Observations Systématiques sur les Saturnioïdes Américains.

Prof. E.-L. Bouvier, Muséum National d'Histoire Naturelle, Paris, France.

(Avec 4 figures.)

La superfamille des Saturnioïdes est un groupe remarquablement riche en espèces séricigènes; c'est pour cela que j'en fais, depuis une dizaine d'années, l'object de mes recherches. Car les séricigènes, à cause de Lyon, intéressent hautement l'industrie française, et d'autre part, nombreux sont encore en France les amateurs ou biologistes qui, à la suite de Guérin-Méneville, se livrent à l'élevage des grands séricigènes exotiques. Combien de fois n'ai-je pas été consulté sur ces insectes au laboratoire d'entomologie du Muséum d'Histoire Naturelle!

Par malheur, les Saturnioïdes réunis dans cet établissement n'avaient jamais été l'objet d'une étude sérieuse, et par ailleurs, je me trouvais pris au dépourvu faute d'une oeuvre systématique d'ensemble relative au groupe. Il y avait bien le volumineux essai publié sous les auspices de la Condition des Soies de Lyon *); il y avait aussi la masse extraordinaire de matériaux accumulés par Packard et réunis par Cockerell **) mais la première de ces études, quoique fort utile, était manifestement insuffisante au point de vue scientifique, et la seconde paraît bien être une riche mine plutôt qu'un édifice. Encouragé par un très sérieux mémoire d'Aurivillius ***) qui avait introduit dans la systématique des formes africaines du groupe une méthode et une précision inconnues jusqu'alors, je résolus d'étudier et de classer la masse assez considérable des Saturnioïdes du Muséum national d'Histoire Naturelle de Paris.

J'ai fait connaître, il y a quelques mois, les résultats de cette étude en ce qui concerne les Saturnioïdes africains †), et je présente aujourd'hui une ébauche de ceux relatifs à la faune américaine, en attendant que soit définitivement réalisé le projet formulé jadis par W. Rothschild ††) d'une étude monographique approfondie des Saturnioïdes.

D'après le Dr. Karl Jordan, qui a réalisé supérieurement une première partie †††) de ce vaste programme, la superfamille des Saturnioïdes

---

*) Essai de classification des Lépidoptères producteurs de soie (*Labor. d'études des Soies de Lyon*, 1895—1905, en 5 fasc. successivement publiés par Dusuzeau, Sonthonnax et Conte).

**) Monograph of the Bombycine Moths of North America, part III, édité par T. D. A. Cockerell (*Mem. Acad. Sciences, Washington*, vol. XIII, 1914).

***) Chr. Aurivillius. — Beiträge zur Kenntnis Insektenfauna von Kamerun (*Ark. f. Zoologi*, Bd. II, No. 4, 1904 (1905).

†) Observations sur la structure et le classement des Saturniens d'Afrique (*Mém. Acad. des Sciences*, T. LIX. 1928).

††) W. Rothschild. — Notes on Saturnidae (*Nov. Zool.* II., pp. 35—51, 1895).

†††) K. Jordan. — A monograph of the Saturnian subfamily Ludiinae (*Nov. Zool.* XXIX, pp. 247—325, 1922).

comprend cinq groupes qui ont respectivement pour types les *Eacles* ou *Ceratocampa*, les *Arsenura*, les *Hemileuca*, les *Ludia* et les *Saturnia*; chacun de ces groupes a la valeur d'une sous-famille, mais les deux premiers constituent par leur ensemble la famille des Cératocampides, les trois autres, celle des Saturniides: comme je l'ai rappelé ailleurs, les représentants adultes de ces divers groupes diffèrent à tel point les uns des autres qu'il semble préférable de les ranger dans autant de familles distinctes. Si bien qu'à mon avis la superfamille des Saturnioïdes comprend cinq familles: les Cératocampidés, Arsénuridés et Hémilucidés, qui sont purement américaines, les Saturniidés, qui sont répandus dans toutes les parties du monde, et les Ludiidés, qui sont propres aux régions tropicales et australes du continent africain.

A l'heure actuelle, au point de vue systématique, les Cératocampidés et Saturniidés ne présentent pas de difficultés spéciales, — et d'autre part des Ludiidés sont actuellement bien connus grâce à Jordan qui leur a consacré le travail monographique impeccable auquel j'ai fait allusion plus haut. Restent les Arsénuridés et Hémileucidés.

Je ne m'arrêterai guère sur la première de ces familles, parce que tous les genres en sont bien connus. Il sera bon d'observer toute fois que je m'en suis occupé à deux reprises différentes: une première fois *) pour y introduire le genre *Paradaemonia* constitué au moyen de formes rangées jusqu'alors dans le genre *Dysdaemonia*, — une seconde, toute récente **), pour donner le nom d'*Anuropteryx* à une forme générique qui tient à la fois des *Arsenura* et des *Machaerosoma*. La première de ces initiatives a été, je crois, heureuse. Mais la seconde le fut beaucoup moins: l'espèce colombienne que j'ai décrite sous le nom d'*Anuropteryx* n'est rien autre que le *Grammopelta cervina* Jordan qui est lui-même synonyme du *Copaxa lineata* Schaus. Or cette espèce n'a rien de commun avec les *Copaxa* qui sont de francs Saturnides; lorsqu'il établit le genre *Grammopelta*, W. Rothschild eut bien soin d'en indiquer les caractères arsénuridiens.

C'est aux Hémileucidés que sera consacrée surtout la présente note et c'est vraiment de tous les groupes de Saturnioïdes, celui qui réclame le plus de lumière, car le désordre et la confusion y règnent, pour ainsi dire, en maîtres. J'ai tenté recemment ***) d'y établir des coupes et des divisions génériques aussi nettes que possible; mon but est de reprendre aujourd'hui cette ébauche pour la rendre plus rationnelle et plus complète, en réduisant l'importance que j'y accordais à la structure des antennes et en étendant mes observations sur les annexes de l'appareil reproducteur des mâles.

Il ne sera pas inutile de rappeler d'abord la structure de ces annexes que le Dr. Jordan a si bien fait connaître dans la famille des Ludiidés. Essentiellement constitués par le volumineux segment 9 (IX) qui porte latéralement une paire de mors appelés claspers (1, 2, 3) et ventralement

*) Nouvelles remarques sur les Saturniens du genre *Arsenura* (*Ann. Soc. Ent. de France*, T. XCIV, pp. 67—72, 1925).

**) *Anuropteryx*, Saturnioïde nouveau de la famille des Arsénuridés (*Bull. Soc. Ent. de France*, février 1928).

***) Sur les Lépidoptères saturniens de la famille des Hémileucidés (*Comptes Rendus Ac. Sci.*, CLXXXVI, pp. 817—820, 1928).

la saillie chitineuse du pénis (p), ils comprennent en outre le 10e ou dernier segment dont la partie tergale, appelée uncus (u), prolonge dorsalement en arrière le segment 9, tandis que sa partie sternale (st. X) se trouve juste au-dessous de l'anus, lequel est ainsi compris entre le tergite et le sternite du segment 10. Ces parties sont d'ordinaire très variables chez les Hémileucidés et d'un vif intérêt pour l'étude des affinités; à ce point de vue, les claspers me paraissent avoir une importance prédominante et méritent d'être étudiés d'un peu près. Situés de chaque côté entre l'uncus et la base du pénis, ils se divisent plus ou moins nettement en trois lobes, l'un supérieur (1) contigu à l'uncus, l'autre moyen (2) plus externe, le troisième inférieur (3) rapproché du pénis. Ces trois lobes sont toujours confondus à leur base, mais chacun d'eux présente des relations spéciales: le supérieur se continue en bas avec le sternite 10, porte rarement une épine, mais peut se transformer en pointe *(Dirphia)*; le deuxième est inerme ou fortement armé d'une épine (fig. 1, e) ou de plusieurs; le troisième se prolonge parfois en une longue épine infra-péniale (fig. 2 a), à laquelle semble prendre part aussi la région contiguë du 9e segment.

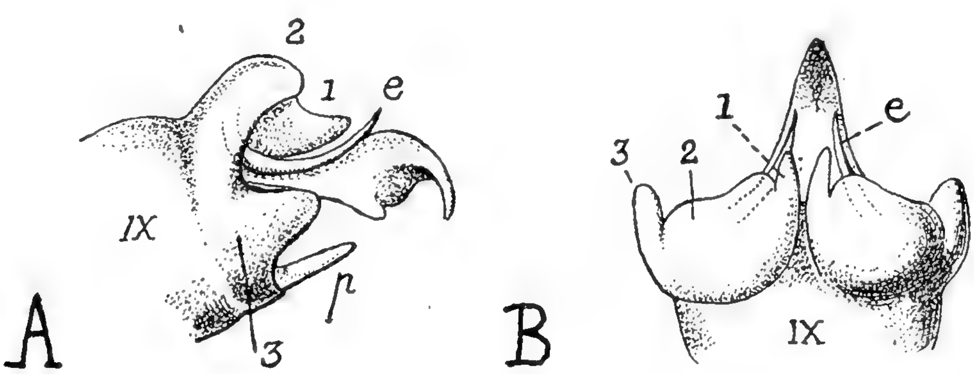


Fig. 1. — *Eubergia caisa* Berg, appareil du mâle: A côté droit, B en dessus; IX = segment 9e; 1, 2 et 3 les lobes des claspers, e = épine du second lobe; p = pénis. L'uncus (tergite du 10e segment) n'a pas de lettre; le 10e sternite est caché.

C'est tout récemment que j'ai observé pour la première fois ce dernier type structural des claspers; il est équivalent aux deux autres et caractérise comme eux, à mon avis, un groupe de première importance. Ainsi la famille des Hémileucidés comprend trois sous-familles, au lieu des deux que j'avais proposées dans ma note: la première, celle des *Automerinae* correspond bien aux Hémileucidés dont le lobe moyen est spinifère (fig. 1),

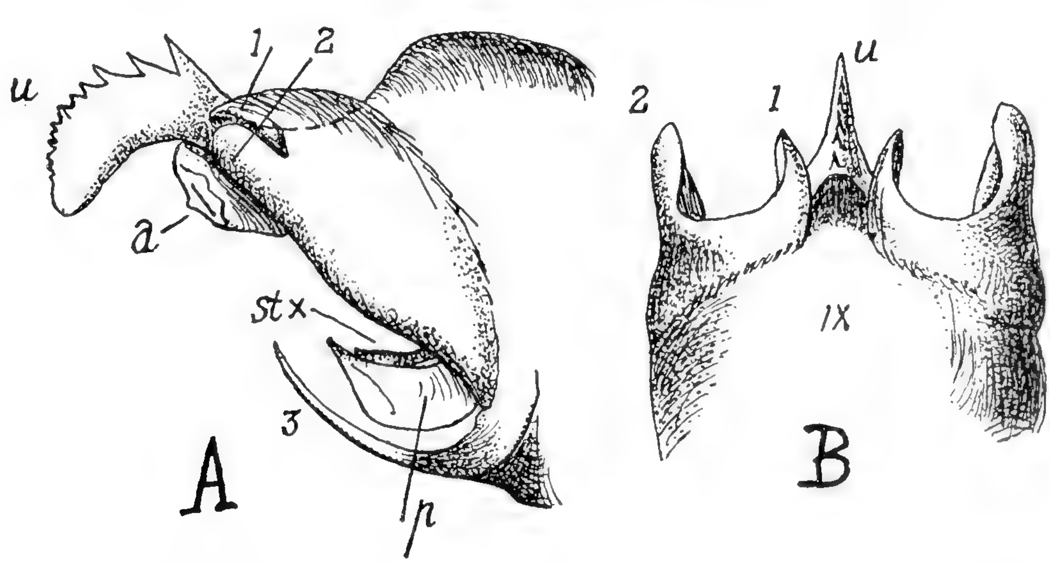


Fig. 2. — *Molippa simillima* Jones, appareil du mâle: A côté gauche, B en dessus; IX = segment 9e; 1,2 et 3 les lobes des claspers, le lobe 3 saillant en longue épine; u = uncus; st. X = sternite du 10 e segment; p. = pénis; a = anus sur la saillie anale.

mais les deux autres embrassent dans leur ensemble toutes les formes que je rangeais dans la sous-famille des Dirphiinés. En fait, il convient de conserver le nom de *Dirphiinae* à la réunion des espèces dont les claspers ne présentent aucune armature spiniforme sur leurs lobes moyens et inférieurs (fig. 3 et 4) tandis qu'on réunira autour des *Molippa,* en une sous-famille des *Molippinae,* toutes les espèces dont le lobe inférieur des claspers se prolonge en épine infra-péniale (fig. 2).

Ceci posé, examinons chacune des trois sous-familles.

I. Sous-famille des *Antomerinae.* — Dans cette sous-famille, les claspers ne sont pas ankylosés sur le 9e segment et leur lobe moyen présente toujours, sur sa face interne, une forte armature épineuse (fig. 1), d'ailleurs très variable suivant les espèces. Les antennes sont toujours quadripectinées et, dans toutes les espèces examinées jusqu'ici, sans carène ventrale bien nette sur la face inférieure de leurs articles; dans les mêmes espèces on observe que les tibias sont dépourvus d'épine fixe et que ceux de la première paire, chez le mâle tout au moins, présentent une épiphyse dont la face inférieure est garnie de poils.

Ce groupe comprend essentiellement les trois genres *Automeris* Hübn., *Hylesia* Hübn. et *Micrattacus* Walk. qui se rattachent étroitement les uns aux autres et constituent un ensemble homogène reconnu par tous les zoologistes. A ce groupe il faut ajouter et réunir sous une dénomination générique nouvelle (je propose *Eubergia)* un certain nombre d'espèces qui ont pour type le *Dirphia caisa* Berg (fig. 1) et qui se distinguent des trois genres précédents par leurs taches discales petites, mais nettes et semblables sur les deux faces de toutes les ailes, et par leur coloration toute spéciale, surtout par la marge colorée qui flanque latéralement leurs nervures. Cette coloration rappelant tout à fait celle de l' *Heliconisa pagenstecheri,* j'avais d'abord attribué les dites espèces au genre *Heliconisa,* et d'autre part, leur armature génitale est tout à fait automérienne contrairement à ce que l'on observe dans le genre *Prodirphia* où je les avais rangés ensuite. A côté du *Dirphia caisa* Berg, il faut ranger dans le genre *Eubergia* une espèce très voisine, l' *Hemileuca baetifica* Druce, dont est vraiment synonyme mon *Heliconisa bedoci,* ainsi que me l'a signalé M. Zerny. Dans l'espèce de Berg, les taches discales présentent un cercle interne arrondi qui leur donne quelque peu la forme ocellaire si fréquente chez les autres Automérinés.

II. Sous-famille des *Molippinae.* — Dans cette sous-famille nouvelle, le lobe inférieur des claspers se prolonge en une longue épine infra-péniale (fig. 2), les deux autres lobes étant inermes et, d'ailleurs, bien développés. Comme dans la sous-famille précédente, les antennes des mâles sont quadripectinées, les tibias dépourvus d'épines et les épiphyses bien développées; mais les taches discales, au lieu de prendre la forme d'ocelles, sont irrégulières, pour ainsi diré délavées, avec une coloration plus forte sur les nervures qui les traversent. L'uncus est très caractéristique avec son armature de denticules ou d'épines, tantôt développé latéralement et alors armé sur sa face et sur ses bords, tantôt dans le plan médian sous la forme d'une lame simple ou bifurquée.

Dans ce dernier cas les taches discales sont grandes et d'ordinaire plus nettes sur les bords, la frange des ailes présente alternativement des taches foncées et des taches claires, en outre, sur la face dorsale du thorax s'élèvent

de longs poils à bout libre lancéolé, c'est le genre *Molippa* Walk. (*sabina* Walk., *simillima* Jones (fig. 2), *basinoides* Bouv.); ou bien les taches discales sont réduites et sans bords plus accentués, les franges claires et les poils thoraciques normaux, c'est le genre *Prodirphia* Bouv., où je ne connais qu'une espèce, l' *Hemileuca strigosa* Maass. et Weym., dont l'uncus est une lame simple denticulée sur son bord supérieur comme dans la *Molippa simillima*. Dans l'autre cas, les taches discales sont foncées et les longs poils du thorax ne paraissent point sensiblement lancéolés; c'est le genre *Rhodormiscodes* Pack. qui a pour type le *R. rosea* Druce.

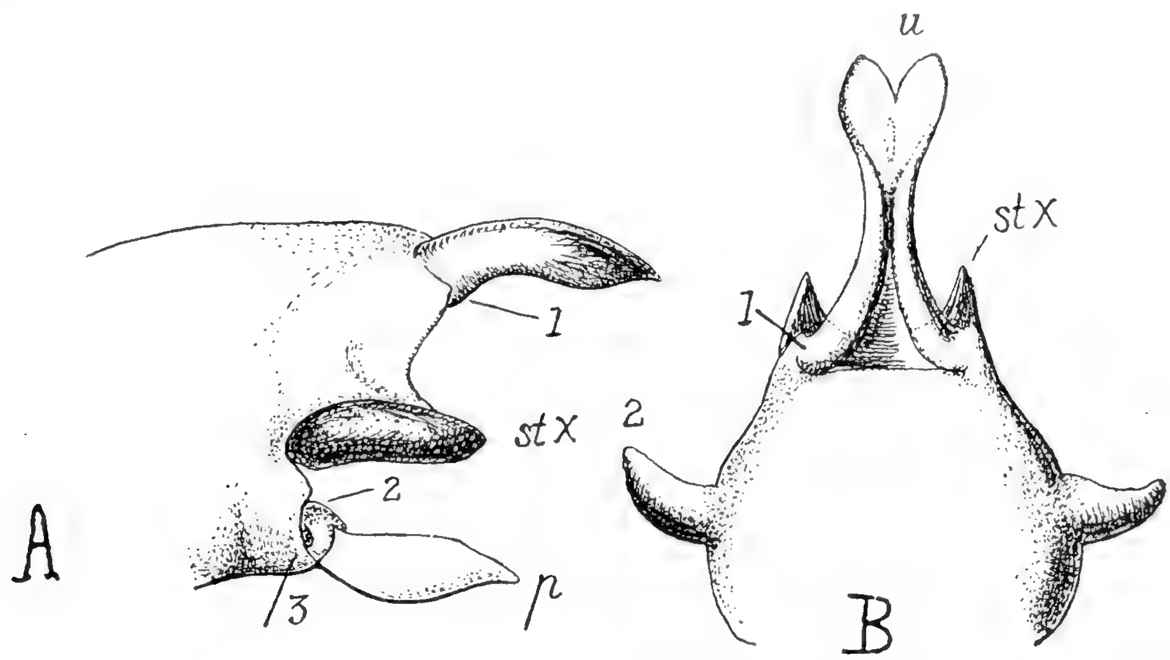


Fig. 3. — *Pseudodirphia agis* Cram., appareil du mâle: A du côté droit, B en dessus; le segment IX (sans lettre) est tout-à-fait fusionné avec les claspers, dont tous les lobes (1, 2, 3) sont très réduits et inermes; st. X = sternite du 10e segment; u = uncus (tergite du 10e segment); p = pénis.

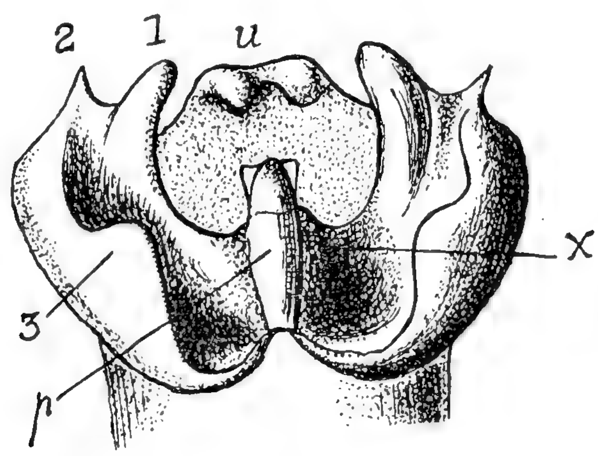


Fig. 4. — *Euleucophaeus burnsi* Wats., appareil du mâle vu du côté ventral: Les claspers, à lobes (1, 2, 3) fort nets, ne sont pas étroitement fusionnés avec le segment IX (qui ne porte pas de lettre); le lobe montre ses relations étroites avec le sternite X; u = uncus; p = pénis.

III. Sous-famille des *Dirphiinae*. — Réduite comme je l'envisage ici par l'éloignement des *Molippinae*, la sous-famille des *Dirphiinae* se distingue des deux précédentes par ses claspers (fig. 3 et 4) dépourvus de prolongements spiniformes sur ses lobes moyens et inférieurs; l'uncus n'y présente jamais les dents ou épines qu'on observe chez les Molippinés, et les taches discales lorsqu'elles existent, n'y sont jamais ocelliformes.

Malgré la réduction qu'elle subit, cette sous-famille est des plus vastes, rivalisant sur ce point avec les Automérinés; elle est d'ailleurs plus variée

que cette dernière, plus riche en formes génériques. Celles-ci peuvent être classées, soit en donnant la prédominance aux antennes, soit d'après les caractères des épiphyses et des claspers qui s'accordent parfaitement. Les deux méthodes conduisent à la même caractérisation des mêmes genres. La première est celle que j'employai dans ma note antérieure, mais elle a l'inconvénient de dissocier les deux phylums dans lesquels se rangent manifestement toutes les formes de la sous-famille. Il convient de recourir à la seconde qui a l'avantage de respecter les deux phylums; ces derniers se rangent autour des genres *Dirphia* et *Hemileuca;* ils ont la valeur de tribus et se subdivisent en groupes secondaires d'après la structure des antennes.

Le phylum des *Dirphia,* ou tribu des *Dirphiicae,* se distingue par la présence constante d'une épiphyse sur chaque tibia antérieur, au moins chez le mâle, par les claspers qui s'ankylosent plus ou moins sur le 9e segment et par le lobe supérieur de ces claspers qui est toujours étroit (en languette ou en pointe), parfois armé d'une épine *(Hylesiopsis),* dans bien des cas très réduit et à peine saillant vers la base de l'uncus (fig. 3); la taille est souvent grande, la forme rappelle les Molippinés, les taches discales sont très variées ou nulles.

Deux groupes dans ce phylum, l'un, *dirphien* avec les antennes quadripectinées, l'autre, *pseudodirphien,* où les articles antennaires n'ont que deux branches.

A la base du groupe *dirphien* se placent les *Ormiscodes* Blanch., qui ressemblent aux *Molippa* par leurs articles antennaires à peu près dépourvues de carène ventrale et leur thorax garni de longs poils très lancéolés; leur épiphyse est nue ou presque nue, absente chez la femelle, leur tache discale tranche en clair sur le fond et leurs claspers trilobés sont assez mobiles sur le segment qui les porte; ils ont pour type l'*O. cinnamomea* Blanch. et comprennent en outre toutes les espèces rangées jusqu'ici dans le genre *Catocephala* Blanch. — Viennent ensuite les très nombreux représentants du genre *Dirphia* Hübn.; les antennes y sont d'ordinaire bien carénées dans leur partie ventrale, les claspers ankylosés sur le 9e segment et les poils thoraciques simples, sauf dans *D. lombardi* Bouv. où les longs poils lancéolés sont très nombreux et dans *D. lasiocampina* Feld. où ces poils ont encore un certain développement; ainsi délimité, le genre *Dirphia* comprend quantité de formes que les entomologistes rangent au petit bonheur dans les *Plateia* Hübn. (type *D. somniculosa* Cram.), *Phricodia* Hübn. (type *D. avia* Cram.), *Thauma* Walk. ou dans le genre *Ormiscodes* Blanch.; il faut y faire rentrer, provisoirement tout au moins, l'*Heliconisa arpi* Schaus, que j'avais à tort rangé dans le genre *Prodirphia.* On pourra sans doute établir des coupes secondaires dans le vaste genre *Dirphia,* et quelques-unes semblent déjà très évidentes (groupe *semirosea-lasiocampina,* groupe *orasia-somniculosa,* groupe *ursina-calchas,* quelques espèces de l'ancien groupe *tarquinia);* mais c'est une question qui, à l'heure actuelle, ne peut être définitivement résolue. Tout à côté de ces Dirphiens inermes se rangent les *Heliconisa* Walk. qui sont des Dirphiens où les tibias antérieurs sont armés distalement d'une forte épine. Les *Heliconisa* se distinguent en outre par la branche antérieure de leurs articles antennaires qui se réduit à un denticule, et leur uncus, à pointe cordiforme, ressemble beaucoup à celui des *Dirphia* du groupe *orasia* Cram.; le genre comprend sûrement les trois espèces suivantes: *H. pagenstecheri* Geyer, qui en est

le type, *H. catharina* Schaus et *H. venata* Butl., jusqu'ici rangé à tort parmi les *Coloradia.* On y a fait entrer beaucoup d'espèces tout à fait étrangères, comme on peut s'en convaincre en jetant un coup d'oeil sur le travail où, en collaboration avec J. Brèthes*), sont passées en revue les formes qui semblaient être alors des *Heliconisa.*

Quant au groupe *pseudodirphien,* caractérisé par les antennes bipectinées, il a pour type le genre *Pseudodirphia* Bouv., qui présente des particularités très frappantes: l'une relative aux ailes antérieures dont la rayure interne part de la base de la costa pour se diriger obliquement en arc vers le milieu du bord opposé, l'autre particulière aux claspers dont tous les lobes sont fort réduits, fusionnés entre eux et avec le 9e segment, l'interne lui-même se détachant peu à la base de l'uncus (fig. 3), sous la forme d'une petite pointe; au genre ainsi défini appartiennent toutes les espèces du groupe *Dirphia eumedide* Cram. (*agis* Cram., *aurora* Vuill., *obliqua* Bouv., etc.). — J'ai proposé de réunir sous le nom de *Dirphiopsis* des espèces à antennes bipectinées qui se distinguent des précédentes par la position normale ou l'atrophie complète de la rayure interne des ailes antérieures. Le genre se rapproche des précédents par deux espèces, *menander* Druce et *dukenfieldi* Schaus dont ils possèdent l'uncus bilobé et quelque peu le facies; il comprend en outre un certain nombre de formes, parmi lesquelles je puis citer *pulchricornis* Walk., *multicolor* Walk. et *epiolina* Feld. — Enfin, je crois qu'il y a lieu de mettre à part, dans un genre spécial pour lequel je propose le nom d'*Hylesiopsis,* une espèce bipectinée de teinte gris rose, reçue de Colombie d'où elle me fut envoyée par le Frère Apollinaire-Marie. Cette espèce, *Hylesiopsis festiva* nov., ressemble quelque peu aux *Hylesia* et aux *Dirphia*, mais s'en distingue par les claspers dont le lobe interne est assez grand, libre et muni sur sa face interne d'une longue épine courbée qui se dirige vers l'uncus comme l'épine analogue produite par le lobe moyen des Automérinés.

Le phylum des *Hemileuca,* ou tribu des *Hemileuciicae,* se distingue par la disparition complète ou presque des épiphyses, par la structure des claspers (fig. 4), dont tous les lobes sont largement développés et assez mobiles sur le segment génital qui les porte; la taille est toujours médiocre, les ailes sont relativement plus courtes et plus larges que chez les Dirphiicés, leurs taches discales moins variées et plus régulières. Comme la tribu précédente, les Hemileucicés se subdivisent en groupes et en genres d'après la structure des antennes et l'armature des tibias antérieurs.

Le groupe où les antennes sont quadripectinées comprend les deux genres *Meroleuca* Pack. et *Coloradia* Blake. Le premier sans trace d'épiphyse, sans carènes antennaires, sans épines aux tibias antérieurs, et représenté jusqu'ici par une seule espèce, *M. venosa* Walk. Le seconde avec une épiphyse mâle rudimentaire ou nulle, les articles des antennes ventralement carénés, les tibias antérieurs armés d'une épine et, dans les deux espèces que j'ai pu étudier (*C. pandora* Blake, *C. loiperda* Dyar), avec l'uncus en pointe bifide.

Le groupe où les antennes sont bipectinées se reconnaît aisément aux taches discales dont le pourtour est foncé et le centre linéaire, blanc ou

*) E. L. Bouvier et J. Brèthes. Sur les *Heliconisa* et leures différences sexuelles (*Rev. Universid. Buenos Aires* (2), sect. V, Vol. 1, No. 14, 1924).

blanchâtre. Il est représenté par les *Euleucophaeus* Pack., dont le tibia antérieur est inerme (*tricolor* Pack., *norba* Druce, *mania* Druce, *oliviae* Cock. etc.); et par deux autres genres où les tibias antérieurs sont armés comme ceux des *Coloradia:* le genre *Hemileuca* où les antennes sont à peu près dépourves de carènes ventrales (*H. maja* Drury), et le genre *Pseudohazis* Grote et Rob. où les articles antennaires sont fortement carénés et les uncus trilobés à leur pointe (*hera* Harris, *eglanterina* Boisd.)

Tels sont les résultats systématiques auxquels m'a conduit l'étude des Saturnioïdes américains du Muséum d'Histoire Naturelle de Paris; puissent-ils réaliser un progrès dans la connaissance, jusqu'ici fort obscure, des divers Hémileucides! J'ai laissé de côté le genre paléarctique *Aglia* que le Dr. Jordan rattache aux Hémileucides, ainsi que les deux genres américains *Catharisa* Jord. et *Cinommata* Butl., dont la position systématique est douteuse.

A new Method of making microscopic Aphid Preparations.

Prof. Dr. W. Roepke, Wageningen, Holland.

In recent times, the study of Aphids has become more popular, not only on account of the injuries which these insects cause to many cultivated plants, but also because many species have shown to be the carriers and spreaders of the so-called virus-diseases.

However, a thorough study of Aphids is far from easy. Their biology offers many and most interesting problems, which are not completely solved yet. Furthermore, their morphology is subject to an extensive polymorphism and also to a certain variability. One and the same species may appear in quite different forms, whilst each form may show a great variability of an individual, seasonal or geographical character.

On the other hand, there are species which are without any doubt quite different and which show differences enough as to their manner of life, but which are morphologically extremely difficult to distinguish. It is, therefore, not astonishing that the systematics of our Old World plantlice, even of some quite common species, are not yet wholly settled, and that the synonymy of many species is very complicated.

There is no doubt that careful modern Aphid investigations in the laboratory can only be done if really good microscopic preparations are made. But many persons who have tried to macerate these soft-bodied insects by the common methods, i. e. in caustic potash, in order to mount them in Canada balsam, will have experienced that such preparations as a rule are not quite satisfactory. The objects are so badly deformed by shrivelling, that they are scarcely suited for a careful study. Most authors agree that really good preparations of Aphids are difficult to make.

We have elaborated at our Laboratory at Wageningen (Holland) a new method by which one can get nearly ideal preparations in a quick, simple and cheap manner.

Living Aphids are killed in alcohol of 70—96%. In the same alcohol, they are heated on a water bath for about 15 min. Then the alcohol is replaced by lactic acid (75%), and heating on the water bath is continued for about 20 min. Smaller forms such as young larvae are macerated enough after this treatment to be mounted on a slide; others, however, which are bigger or contain more fatty substances, must be treated further in order to destroy the tissues more completely. For this purpose, they are transferred from the lactic acid directly into a mixture of chloral hydrate crystals and melted crystals of phenolum liquefactum (about equal parts). In this mixture the specimens are further heated on the water bath until the soft tissues are completely destroyed, which takes from about 10 to 30 min.

Aphid material which has already been preserved in alcohol for some time must be treated longer in both macerating fluids; boiling in alcohol, however, may be omitted. Eventually intermediate treating with caustic potash may be necessary, if the material is very old.

Especially in the lactic acid the objects swell up so that all integumental structures become clearly visible. The phenol mixture destroys the remnants of the soft tissues completely and dissolves the fat body.

Common test tubes are used for the different treatments.

Mounting takes place in the so-called Berlese fluid, which is a modification of the old and well known gum arabic mixture by Faure. The Berlese formula runs as follows:

gum arabic	12 g	
aq. dest.	20 g	
glyc. conc.	8 g	(or 6 cc)
chloral hydrate	20 g	

When mounting from lactic acid only, a short rinsing in water is advisable in order to avoid lactic acid crystals in the mounting fluid. Too long rinsing may cause shrivelling. From the phenol mixture, the objects are directly put into a drop of Berlese fluid on a slide, and after spreading the legs, &c., in an convenient position, a cover slip is placed on them.

It is a good practice to ring the preparations, though in a dry climate it is perhaps not absolutely necessary. In a damp climate, ringing must take place after the preparations have been kept for some days in a dry stove or in an exsiccator.

Fresh preparations may also be ringed by dipping them first in alcohol of 96% for some minutes; immediately after the alcohol is evaporated, the ringing fluid must be applied. We use for this purpose an alcohol resisting resinous mixture, called Murrayite, from Mssrs. Flatters & Garnett, Manchester, England.

Perhaps our method may not give preparations which keep as long as objects in Canada balsam, but it affords the great advantage that such tiny and delicate insects as Aphids do not shrivel at all and that a good orientation of all parts of the body is possible without breaking them. On account of its simplicity and cheapness — as no alcohol is used for mounting — the method is very suitable for making long series, or when working with a large number of students, &c.

Mounting in Euparal has given satisfactory results with bigger Aphids. From the phenol mixture they were transferred into aceton and through this medium mounted in Euparal.

It is evident that the above described method is also suitable for many other small insects, or for portions of their bodies, such as heads, mouth-parts, genital appendages, &c.

The Significance of Odonate Larvae for Insect Phylogeny.

Professor Philip P. Calvert, University of Pennsylvania, Philadelphia, Penna.

(With 7 text-figures.)

If the exuvia[1]) of an air-breathing insect larva, such as a *Cicada*, be opened and its internal surfaces be examined, the linings of the tracheae are plainly visible as a white cord along each side of the body. If the exuvia be soaked in water for some hours, it is easy to disentangle this apparent cord into ten tubes, each of which is connected with a spiracle (text-

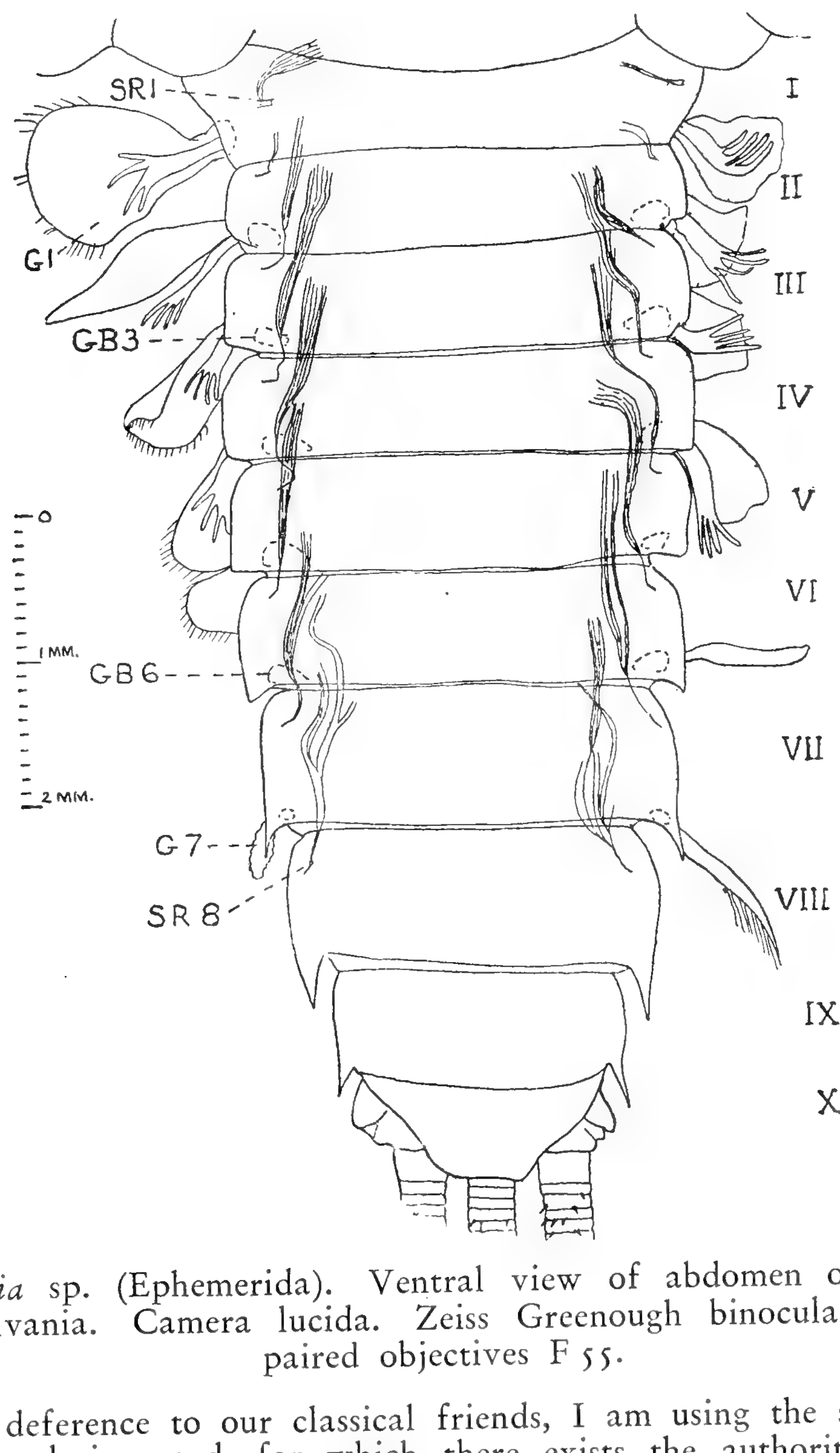


Fig. 1. *Heptagenia* sp. (Ephemerida). Ventral view of abdomen of exuvia of larva, Cheyney, Pennsylvania. Camera lucida. Zeiss Greenough binocular, paired oculars 4, paired objectives F 55.

[1]) With all deference to our classical friends, I am using the singular form *exuvia* as a technical, neo-latin word, for which there exists the authority of the late Prof. John B. Smith's *Explanation of Terms Used in Entomology*, Brooklyn, 1906, page 48

figs. 4, 5) [1]). Two of these spiracles are on meso- and metathorax respectively, the others on the first eight abdominal segments. These tubes undergo no diminution in calibre as they approach their respective spiracles and an examination of the external surface of the exuvia shows that all ten pairs of spiracles are open and functional.

If the older exuviae of water-breathing insect larvae, such as those of May-flies (Ephemerida, text-fig. 1) and dragon-flies (Odonata, text-figs. 6, 7) be compared with those of Cicadas, a similar, but not identical, condition is found. In these two groups the chitinous intima of the tracheae likewise forms an apparent cord on each side of the body and here also, after soaking in water, each lateral cord is separable into ten tubes, each tube corresponding to a spiracle, on mesothorax, metathorax, and each of the first eight abdominal segments.[3]) But, in contrast to the Cicada's exuvia, firstly, each tracheal lining (tube) abruptly narrows in diameter, when within a short distance of its spiracle, and secondly, the spiracular openings are very small and, most of them at least, not functional.

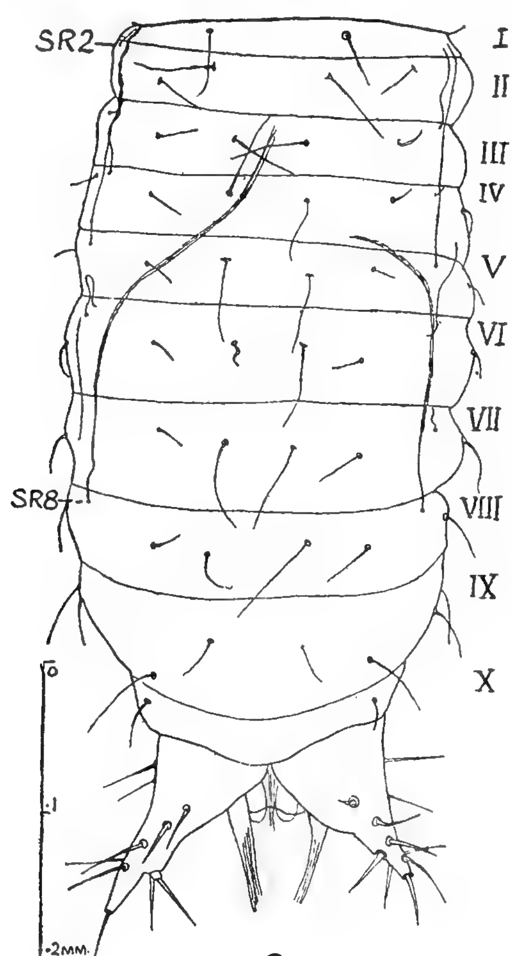


Fig. 2. *Nannothemis bella* (Uhler, Odonata). Ventral view of abdomen of first exuvia of larva no. 57, reared from eggs laid at Chatsworth, New Jersey. SR2, right side, added from exuvia of larva no. 51; not certain of that of left side, nor of those of segment I. Camera lucida; Zeiss compound microscope, draw-tube out to 200 mm., oc. 4, obj. A; finer details added free-hand with draw-tube in to 138 mm., oc. 4, objs. C. and DD.

[2]) On all the figures:

G1—G7, Gills of the 1st to 7th abdominal segments.
GB3—GB6, Bases of the tracheal gills on the dorsal surface of abdominal segments III—VI.
S1—S8, Spiracles (stigmata) of abdominal segments I—VIII.
SR1—SR8, Rudiments of the spiracles of abdominal segments I—VIII.
ST2, ST3, Spiracles of the 2nd and 3rd thoracic segments I—X, 1st to 10th abdominal segments.

[3]) In some Ephemerida and Odonata spiracles are absent from the first abdominal segment.

All these things were known to Palmén fifty years ago and are described in his well known book of 1877. The contracted portions of the tracheal linings extending to the rudimentary spiracles he called thin colorless threads or strings (dünne farblose Fäden oder Stränge, p. 10), attachment threads (Anhaftungsfäden, p. 38) or funiculi (p. 147). He pointed out that the tracheal gills by which larval Ephemerida, Perlaria and Odonata breathe, have no genetic relations with the stigmata which function in their respective adults (pp. 21, 40, 70). He drew the conclusion that the so-called closed larval tracheal system of these three groups is relatively secondary and arose phylogenetically from an open tracheal system of the oldest insects (p. 72).

Palmén states: the strings are formed simultaneously with the tracheal trunks in the young larvae (p. 71), but he does not specify how young the larvae are in which they can first be detected. Among authors who have described the earliest post-embryonic stages of the Ephemerida, Lubbock (1863) was unable to find any tracheae in *Chloëon dimidiatum* earlier than the fourth instar, although he noted "the first appearance of the branchiae" in the "third state". La Baume (1909) likewise observed the gills first after the second moult of *Cloëon dipterum.* Murphy (1922) noted that a nymph of the first instar of *Baetis posticatus* has no gills. Gros (1923) says of the first "larvule" stage of *Ecdyonurus forcipula:* no trace of tracheo-branchiae, respiration cutaneous, the second stage is the initial one of such gills. Wiebe (1926), in his account of the first three larval stages of *Hexagenia bilineata,* says that stage I "showed as far as I could discover, no trace of either trachea or gills .... Gills made their appearance as little evaginations of the body wall ..... along the posterior angles of segments 2—7" in stage II, "but no traces of tracheae are found in either the gills or the body cavity"; in Stage III, "the tracheal system makes its first appearance" and some description of it is given, but no mention is made of spiracular rudiments or the tracheae running to them. On the other hand, in his account of the newly hatched larva of *Ephemera vulgata,* Heymons (1896a), after remarking that no external gills are yet present, states that the entire tracheal system is already laid down, but still stands on a very primitive stage of development; the tracheal trunks consist only of strings of elongated cells and air is not yet present in these rudiments; he adds that six pairs of lateral tracheal gills appear on abdominal segments 2—7 after the first moult.[4]) Dürken (1923), who has given the fullest description of the early larval stages of any Ephemerid, reports that neither in living larvae of the first stage of *Ephemerella ignita,* nor in preserved and stained total preparations of the same age, was he able to see anything of the tracheal system, but in sections he found the tracheae to consist of homogeneous strings of strongly granulated, nucleated plasma, without lumen or intima, extending on each side of the body from the thorax through the entire length of the abdomen; in each of segments 2—8 of the latter a subbranch extends to the ventral hypodermis and this point of union is the site of the future spiracle or stigma, situated far forward on each segment. In the second larval stage a cavity begins to appear in the longitudinal tracheae, but there are as yet no openings to the ab-

[4]) See, however, Dürken's (1923, pp. 595—6) remarks on this statement.

dominal spiracles and no tracheal gills and not even a rudiment of the future tracheae which will supply those gills. The first tracheal gill appeared in the third stage, on the hind lateral margins of abdominal segment 7, and in the following stage a tracheal branch was observed sprouting out toward this gill. The youngest exuviae which he obtained showing the tracheal linings within them were of the seventh stage.

In contrast with the May-fly larvae, the tracheae appear in the embryo of the Odonata as Packard (1868) first observed and figured. To this Heymons (1896b) added that the typical ten pairs of stigmata are to be seen in the embryo. Air first appears in the tracheae soon after hatching (Calvert 1898). I am now able to add that I have found in the first larval exuviae of *Nannothemis bella* (text-fig. 2), *Anax junius* and of

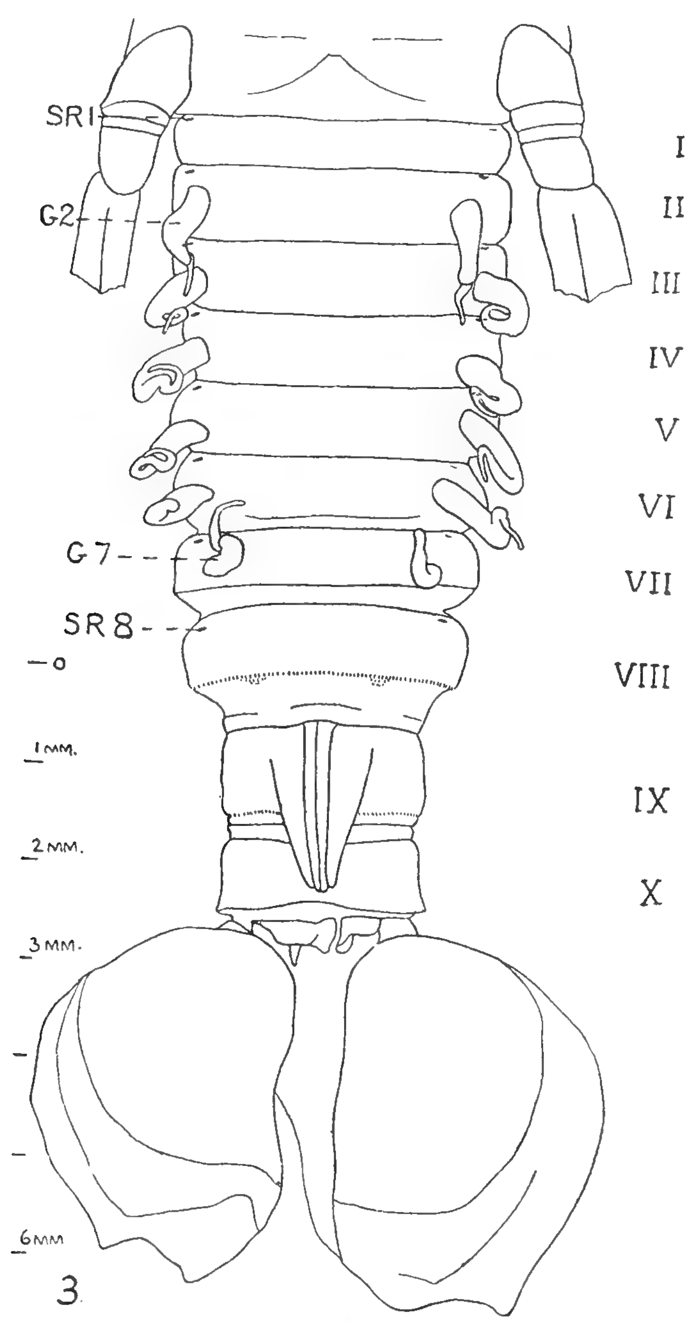
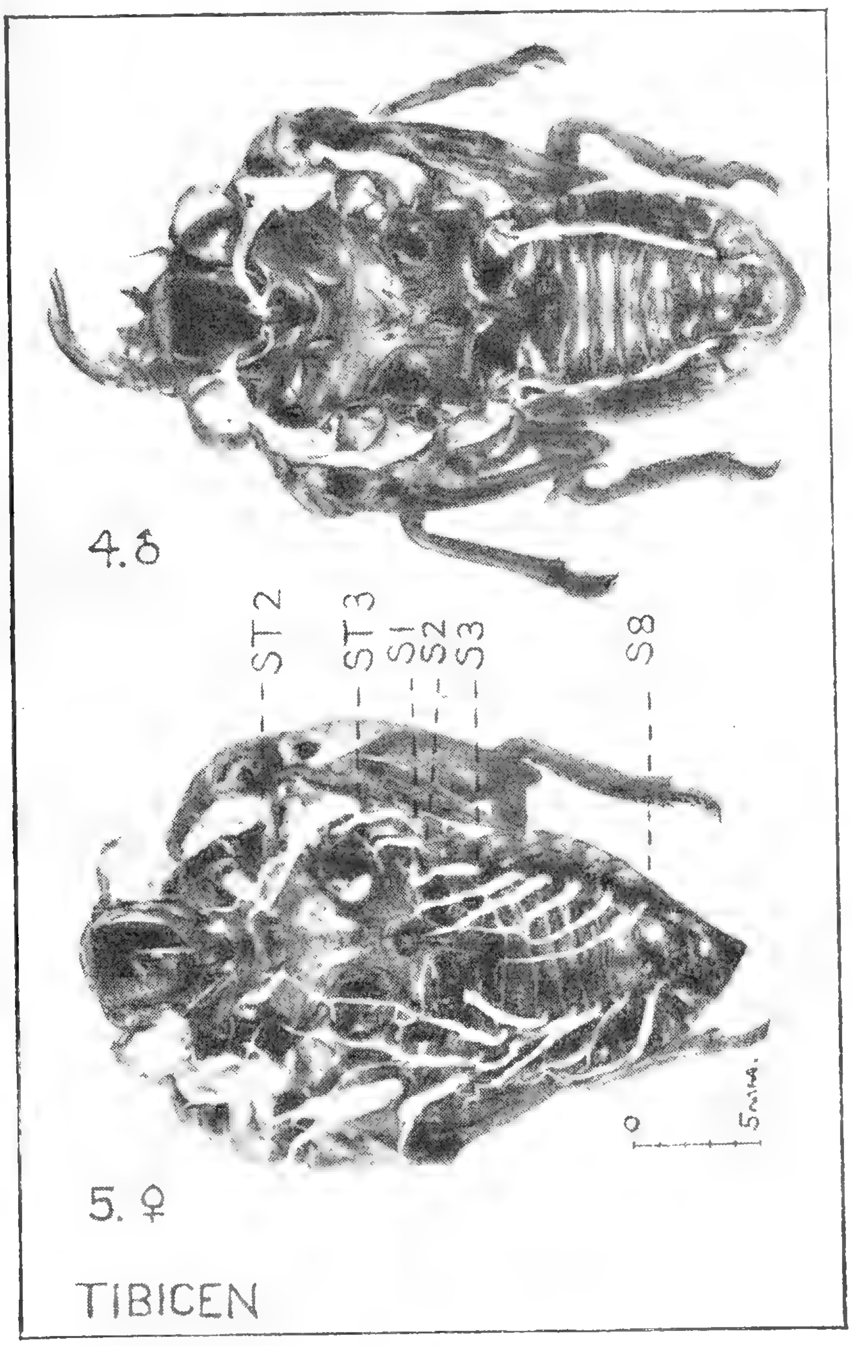


Fig. 3. *Cora (chirripa?)* (Odonata). Ventral view of abdomen of female Larva, Juan Viñas, Costa Rica, May 2, 1910. Camera lucida; Zeiss Greenough binocular, paired oculars 2, paired objectives ao.

a species of *Aeshna*, the spiracular rudiments and the chitinous linings of the tracheae running to those rudiments in some or all of abdominal segments 2 to 8 inclusive. As Palmén (1877, pp. 13—15) and Hagen (1880a, p. 178) recognized, the linings of these tracheae are withdrawn through the spiracles at each subsequent moult, so that Tillyard's state-

ment (1917, p. 88) that the tracheal cords connected with the abdominal spiracles remain solid until metamorphosis is incorrect. In a balsam mount of a first instar larva of *Anax junius* I can detect the spiracular rudiments in segment 8. Further, a renewed study of the (probably nearly full-grown) gill-bearing larva of *Dora* shows that abdominal segments 1—8 each bear a pair of spiracles close to their anterolateral ventral angles (text-fig. 3; compare Calvert 1911, pl. II, fig. 15, pl. III, fig. 20). This is therefore in accord with what exists in the gill-bearing larva of *Euphaea*,

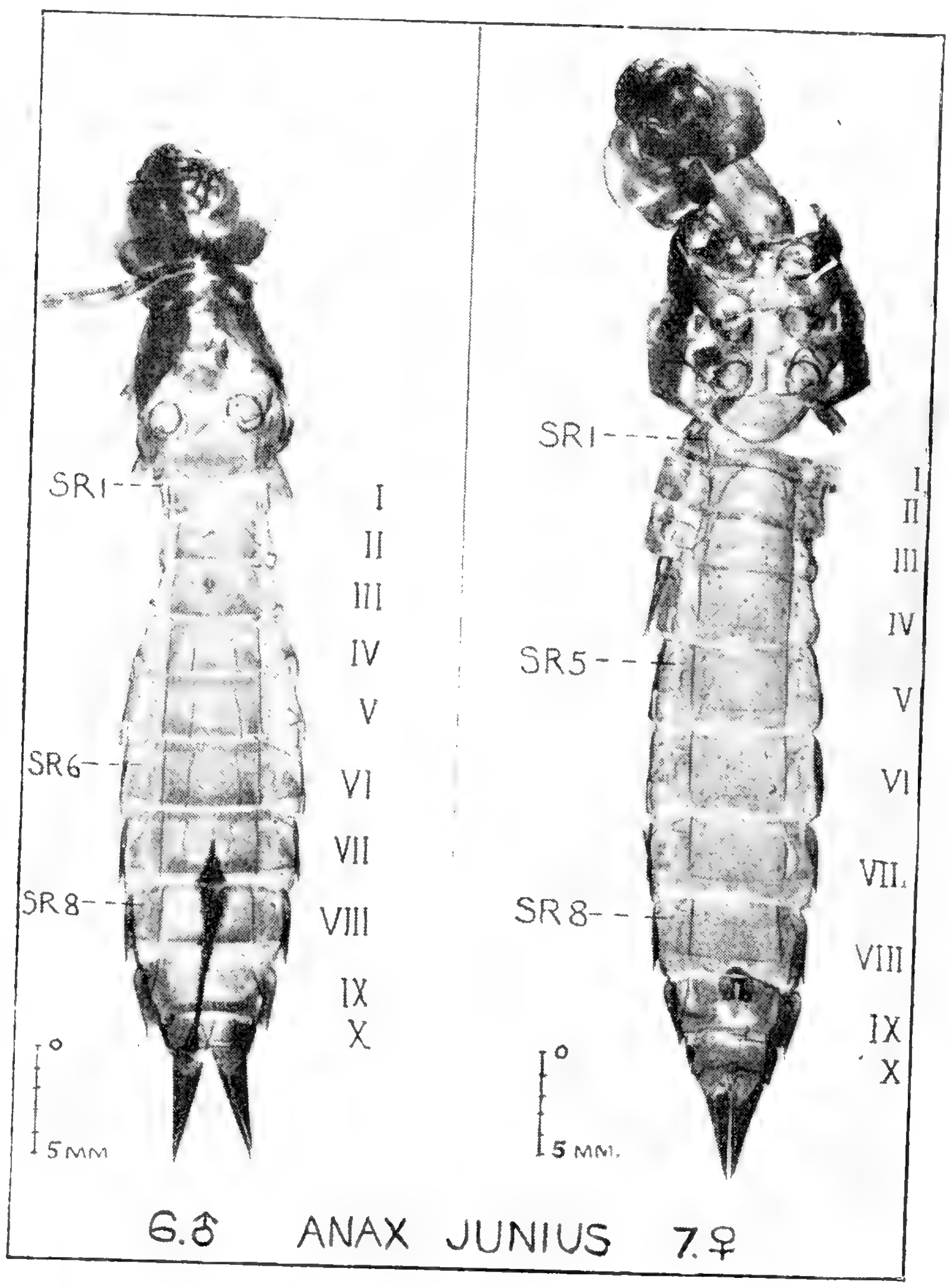


Figs. 4 & 5. Male and female respectively of *Tibicen* sp. (Cicadidae). Last larval exuviae opened and dorsal wall removed to show the tracheal linings attached to the spiracles, Cheyney, Pennsylvania. In fig. 4, these linings are left undisturbed, as they were after the last moult; in fig. 5, the linings are separated from each other, after soaking the exuvia in water, to show their connections with their respective spiracles.

now *Pseudeuphaea* (Hagen 1880 b). As far as physological research has gone, the larvae of both Ephemerida and Odonata agree in not making use of the abdominal spiracles, but respire by the skin, by dorsal, ventral or caudal, external, tracheal gills, or by the rectum which, in the Odonata Anisoptera, is elaborated into tracheal gills. In both groups these tracheal gills, external or rectal, are often complicated structures. Nevertheless, preceding, or perhaps in some cases contemporaneous with, the first

appearance of such gills, the rudiments of the abdominal spiracles are formed. There seems to be no escape from Palmén's conclusion that the Ephemerida and Odonata are, therefore, derived from ancestors which used these spiracles and that implies air-breathing ancestors.

Both the Ephemerida and the Odonata are generally regarded as among the lowest of the winged insects, although views as to the closeness of their relationship to each other are diverse. If they are relatively primitive Pterygota, then whatever opinion may be held as to the ancestry of the



Figs. 6 & 7. Male and female respectively of *Anax junius* (Drury) (Odonata). Last larval exuviae from Half Moon Lake, Pocono Pines, Pennsylvania, treated similarly to those shown in figs. 4 and 5, 6 corresponding to 4 and 7 to 5.
Figs. 4—7 photographed from nature by Mr. A. R. Apgar.

Pterygotes — whether Crustacean, Polychaete, Trilobite, or Chilopod — the evidence from the early appearance of the abdominal spiracular rudiments in these two orders surely points to their more immediate ancestors being air-breathing Articulates. This conclusion is entirely independent of whether those Odonate groups with paired ventral, external, abdominal gills are, or are not, primitive within their own order.

Literature.

1. Calvert, P. P. — 1898. Odonata. The first filling of the tracheae with air; in Ent. News, 9, p. 73.
2. id. — 1911. Studies on Costa Rican Odonata. I. The Larva of Cora; ibid., 22, pp. 49—64, pls. ii, iii.
3. Dürken, B. — 1923. Die postembryonale Entwicklung der Tracheenkiemen und ihrer Muskulatur bei Ephemerella ignita; in Zool. Jahrb., Abt. Anat. 44, pp. 439—614, Taf. 26—28, 30 Textabbild.
4. Gros, A. — 1923. Études sur les Premiers Stades des Ephémères du Jura français; in Ann. Biol. Lacustr., 12, pp. 49—74, 12 figs.
5. Hagen, H. A. — 1880 a. Beitrag zur Kenntniss des Tracheensystems der Libellen-Larven, in Zool. Anzeig. 3, pp. 157—161.
6. id. — 1880b. Essai d'un Synopsis des Larves de Caloptérygines; in Comp.-rend. Soc. Ent Belg. 1er mai 1880, pp. LX—LXVII.
7. Heymons, R. — 1896a. Über die Lebensweise und Entwicklung von Ephemera vulgata, in Sitzber. Gesell. Naturforsch. Fr. Berlin, 1896, pp. 82—96.
8. id. — 1896b. Grundzüge der Entwicklung und des Körperbaues von Odonaten und Ephemeriden; Anhang Abh. König. Preus. Akad. Wiss. Berlin, 1896, 66 pp., 2 Taf.
9. La Baume, W. — 1909. Über die Metamorphose der Ephemeriden; in Sitzber. Gesell. Naturforsch. Fr. Berlin, 1909, pp. 137—153.
10. Lubbock, J. — 1863. Development of Chloeon (Ephemera) dimidiatum; in Trans. Linn. Soc. London, 24, pp. 61—78, pls. 17, 18; 25 p. 477—492, pls. 58, 59.
11. Murphy, H. E. — 1922. Notes on the Biology of some of our North American Species of May-flies; in Bull. Lloyd Libr. No. 22, pp. 46 pp., 7 pls.
12. Packard, A. S. Jr. — 1868. On the Development of a Dragonfly K (Diplax); in Proc. Boston Soc. Nat. Hist., 11, pp. 365—372, 7 figs. Also, more briefly, in Amer. Nat. 1, pp. 676—680, 6 figs.
13. Palmén, J. A. — 1877. Zur Morphologie des Tracheensystems. Helsingfors J. C. Frenckell & Sohn. Pp. x, 149, 2 Taf.
14. Tillyard, R. J. — 1917. The Biology of Dragonflies (Odonata or Paraneuroptera). Cambridge: at the University Press. Pp. xii, 396 4 pls., 188 text-figs.
15. Wiebe, A. H. — 1926. The first three larval stages of Hexagenia bilineata Say; in Ohio Jl. Sci., 26, pp. 267—275, 1 pl.

A Cold Steam Orchard Spraying Machine.

R. W. Leiby, Raleigh, North Carolina.

(With 2 text-figures.)

The cold steam orchard sprayer is operated by a steam boiler of 5 horse power capacity. The steam is generated by a gasoline or fuel oil burner. Spraying is done satisfactorily at from 80 to 100 pounds steam pressure. The boiler is fitted with an injector. On the chassis are also mounted a 150 gallon wooden tank to contain the spraying liquid, a 25 gallon wooden tank to carry water for the boiler, and a cylindrical metal tank to supply gasoline or fuel oil under low air pressure to the burner. A compartment between the fuel and spray tanks and under the water container, furnishes space for a steam driven agitator.

Steam is generated to operating pressure within fifteen minutes in the boiler and conducted through one lead of hose to a venturi nozzle. The spraying liquid is "pulled" to the same venturi nozzle by the steam, where it is broken up into a mist as fine as steam itself, or into a coarse wet spray, the fineness of the spray depending upon the amount of steam that the operator permits to pass to the nozzle. If approximately one part of water, as steam, is used to break up three parts of the spraying liquid, the resulting spray will be almost as fine as steam itself. In this event, one steam nozzle does about 90% of the work of two high pressure sprayer nozzles, in time consumed and area covered. The steam sprayer has the very decided advantage of, first, saving spraying materials, and, second, applying the spray where it belongs in uniform quantities. If about three times the above relative quantity of spraying liquid is permitted to pass to the nozzle, the spray will be somewhat finer than that secured by the average sprayer operating at 250 to 300 pounds pressure. Any degree of fineness or coarseness of spray is available to the nozzle operator by opening or closing a valve which regulates the amount of steam entering the nozzle near its aperture.

The spray escapes with enough force to carry the fog-like mist considerable distances. The enveloping character of the resultant mist covers both sides of the leaves as a fog would do, and settles so gently that no harm is done to the bloom even at its calyx stage. The temperature of the spray at twelve inches from the nozzle is slightly below that of the atmosphere.

Slightly more gasoline is required to operate the steam boiler than to run the average gasoline engine of a high pressure sprayer. This extra operative cost is more than compensated by the following advantages, 1) absence of moving parts; 2) absence of pump and gasoline engine and therefore a freedom of costly and vexatious delays; 3) lower upkeep; and

4) a decided saving in the amount of materials used. If fuel oil is employed under the boiler, the cost of fuel is less than that of gasoline used in high-pressure-sprayer gas engines.

The first cost of the Cold Steam Sprayer is at present greater than that of the average orchard high-pressure-sprayer. It would appear, ho-

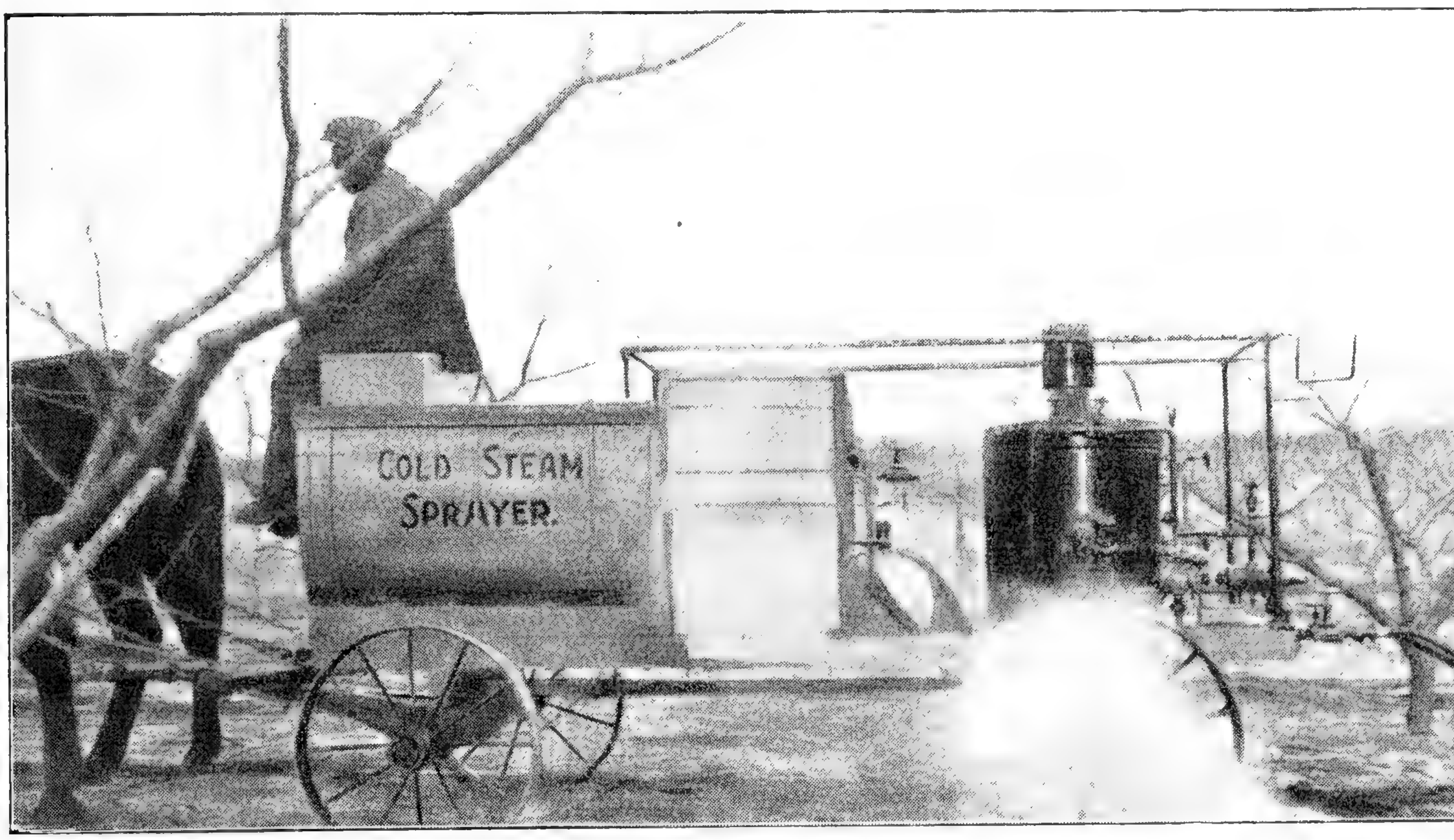


Fig. 1. — Spraying Machine.

Fig. 2. — Misting the trunk of a tree, using the steam sprayer nozzle.

wever, that the steam sprayer would give longer service. Moreover, the uses of steam about the farm in connection with a movable spraying tank are varied. Among them are, cleaning vessels, applying a thin film of oil

or paints to farming machinery or buildings for protective purposes, white-washing or disinfecting buildings, or cleansing motors of grease.

Field tests conducted over a period of two years including the dormant and summer sprays, have shown that insecticides and fungicides can be applied by the steam sprayer as effectively as with the high-pressure-sprayer. Moreover, this is accomplished by a saving of from 30 to 40 per cent of the spraying material, because the spray can be controlled so as to prevent wastage by dripping. It would appear entirely possible uniformly to distribute a definite quantity of the basic insecticides and fungicides of a given formula upon an acre of trees, in half the quantity of water or carrying liquid, now required or used to distribute the same quantity of insecticides and fungicides by means of the pressure-sprayer. This has been done in the case of a dormant spray of lime-sulphur where the dilution was only one-half that usually made for the dormant lime-sulphur spray. Less than one-half of the usual amount of spray was applied per tree at the reduced dilution, but with equally good results as when the regular amount was applied by the high-pressure-sprayer at the usual dilution.

Because of the possibility of applying a suspended solid or any liquid in an extremely finely divided condition and in small amounts, it appears possible to spray such a suspended solid or any liquid safely on a tree without foliage injury, which would be severely injurious to the same foliage when applied with a high-pressure-sprayer. For example, pure kerosene has been applied to sycamore trees in foliage without injury and with a decided benefit to the tree.

Arthropods in the Transmission of Tularaemia.

Edward Francis, M. D., Hygienic Laboratory, U. S. Public Health Service, Washington, D. C.

(With 7 text-figures.)

Tularaemia is an infectious disease caused by *Bacterium tularense.* Primarily it occurs in nature as a fatal bacteremia of wild rodents, especially rabbits and hares. Secondarily it is a disease of man, transmitted from rodents to man by the bite of an infected bloodsucking fly or tick, or by contamination of his hands or his conjunctival sac with portions of the internal organs, or with the body fluids of infected rodents, flies or ticks.

HISTORY (1) AND SYNONYMS.

Discovered by the United States Public Health Service, tularaemia has been elucidated from beginning to end by American investigators alone.

McCoy (2) in 1911 contributed the first scientific knowledge of the disease by his description of "plague-like disease of rodents" which he encountered in the California ground squirrels. McCoy and Chapin (3) (4) in 1912 discovered the causative microorganism which they named *Bacterium tularense,* after Tulare County, California, whence came principally the infected ground squirrels. They furnished serological proof of the infection in two laboratory workers and reported experiments on transmission by the flea *Ceratophyllus acutus.*

Pearse (5) in 1911 described clinically under the title "insect bites" six human cases which occurred in his practice in Utah, where the disease became popularly known as "deer-fly fever".

Vail (6) of Cincinnati reported in 1914, under "*Bacillus tularense* infection of the eye", the first case in man to receive bacteriological confirmation by the insolation of the organism.

Wherry and Lamb (7) (8) (9) made the bacteriologic diagnosis in Vail's case. They also isolated the organism from two wild cotton tail rabbits found dead in Southern Indiana, thus furnishing the first proof of the wild rabbit reservoir of infection.

Martin (10) (11), an ophthalmologist of Arizona, had already called attention by correspondence, in 1907, to five human cases occurring in his practice and contracted from jack rabbits.

Francis (12) (13) (14) in 1919 and 1920, working in Utah, recognized the identity of "deer-fly fever" and "plague-like disease of rodents" and named the disease tularaemia on account of the presence in the blood of *Bacterium tularense.* He isolated the organism from seven human cases and from 17 jack rabbits and, with Mayne (15), demonstrated the agency of *Chrysops discalis* in transmission.

Parker and Spencer (16) (17) (18) (19) (20) reported the agency of the ticks, *Dermacentor andersoni and Haemaphysalis leporis-palustris*, in the maintenance and transmission of the infection and demonstrated hereditary transmission through the egg of the tick.

Ohara (21) in 1925 reported a disease of rabbits and man occurring in Japan which was proven by Francis and Moore to be tularaemia.

Francis (22) (23) (24) (25) in recent articles has brought up to date the various features of the disease.

GEOGRAPHIC DISTRIBUTION.

Naturally infected human cases have been reported from Washington, D. C., and from forty-one states of the United States extending from the Atlantic to the Pacific Coast and from the Canadian to the Mexican border. Twenty-five states were added to the list in 1925 and 1926, five in 1927, and four in 1928. The disease was described in Japan in 1925 and in Russia in 1928. No other country has recognized the infection.

ZOOLOGIC DISTRIBUTION IN NATURE.

(1) Ground squirrels, (2) wild rabbits and hares, (3) wild rats, (4) wild mice, (5) sheep (26), *Ovis aries*, (6) quail (27), *Colinus virginianus* and (7) the fur-bearing water rat (28) or water vole of Europe, *Arvicola amphibius*, have been found infected in nature with *Bacterium tularense*.

(1) The California ground squirrel, *Citellus beecheyi* Richardson was the animal in which McCoy discovered the disease in 1910. His original description was based on a study of forty-two naturally infected ground squirrels. One specimen of *Citellus mollis* was found infected in Utah by Francis. Squirrels in other parts of the United States have not been found infected.

(2) Wild rabbits and hares. Cotton tail rabbits *(Sylvilagus)*, jack rabbits *(Lepus)* and snowshoe rabbits *(Lepus bairdi)* constitute the great reservoir of infection. Every part of the United States is a habitat for at least one species of rabbit or hare. Wherry and Lamb cultured *B. tularense* from guinea pigs which had been inoculated from two wild cotton tail rabbits found dead in Southern Indiana. Francis cultured *B. tularense* from guinea pigs which had been inoculated with (a) the spleen of a snowshoe rabbit found sick in Montana, and (c) the livers of ten cotton tail rabbits bought in the Washington. D. C., market (29). Numerous observers have reported sick and dead rabbits in communities where human cases of tularaemia were occurring. Numerous cases of tularaemia have been reported in persons who had dressed wild rabbits only a very few days previous to illness.

Ohara in 1925 reported a fatal disease of wild rabbits in Japan. The heart of a rabbit found dead was used by him to inoculate a volunteer human subject who contracted tularaemia.

Domestic rabbits raised in rabbitries and sold for food or for laboratory purposes, or to fanciers, have never been found naturally infected, although they are highly susceptible to the infection by inoculation in the laboratory.

(3) Wild rats. F. Dieter and Rhoades (30) in 1925, while engaged in the routine examination of rats for plague in Los Angeles, Cali-

fornia, cultured three strains of *Bacterium tularense* from guinea pigs into which they had inoculated the tissues of wild rats which had been trapped in the city of Los Angeles. This is the only record of having found the infection in wild rats *(Rattus* sp.).

(4) Wild mice. Perry (31) in September, 1927, isolated *Bacterium tularense* by guinea pig inoculation from two wild meadow mice in Contra Costa County, California, where large numbers of sick and dead mice had been observed. This is the only record of having found the infection in wild mice.

TRANSMISSION TO MAN.

Transmission of tularaemia to man occurs (1) by the bite of the horse fly, *Chrysops discalis;* (2) by the bite of the wood tick, *Dermacentor andersoni* Stiles; 3) by the bite of a tick (probably *Dermacentor variabilis);* 4) by contamination of his hands or his conjunctival sac with portions of the international organs or with the body fluids of infected animals, flies or ticks; and 5) by the bites of animals.

(1) Fly bite: *Chrysops discalis.* — June to September are the months recorded for the onset of 23 cases due to fly-bite in Utah and the surrounding states and are the months corresponding to the season of greatest activity of *Chrysops discalis* Williston which is found in that area. This is a blood-sucking fly commonly found on horses and cattle, but it also bites rabbits and man.

(2) Tick bite: *Dermacentor andersoni.* — March to August are the month recorded for the onset of 33 cases due to tick bite in Montana and the surrounding states and are months of greatest activity of the common wood tick, *Dermacentor andersoni,* of that area.

(3) Tick bite: probably *Dermacentor variabilis.* — February to October have been the months of onset of 19 cases due to tick bite occurring in Louisiana, Texas, Oklahoma, Arkansas and Tennessee, the cases occurring in the extreme months of the season having been in the most southern state, Louisiana.

(4) Contamination, or self-inoculation, has caused 671 American cases. The specific acts by which man inoculates himself are the following: A market man skins and dresses rabbits for his patrons. A housewife, servant, or cook dresses rabbits for the table. A hunter dresses rabbits at the end of a day's hunt. A farmer pulls infected ticks from his horse or cow and then touches his eyes. Jack rabbits are skinned and cut up for fish bait, coyote bait, fox feed, chicken feed, hog feed, dog feed, for the table and the market. Persons who have become infected in the laboratory have either performed, or assisted at, necropsies of infected guinea pigs, rabbits or white mice, or have held infected living rabbits or guinea pigs, or have handled infected living ticks.

In addition, two cases followed the skinning of musk rats, *Ondatra zibethica,* two cases followed the skinning of opossums, *Didelphis virginiana,* many cases in Russia followed the skinning of the water rat or water vole of Europe, *Arvicola amphibius,* one case followed the killing and skinning of a woodchuck *(Marmota flaviventer)* and one case followed the scratch of a cat. There is no report of transmission from ground squirrels, mice or rats to man, although the disease has been known to exist in the California ground squirrel since 1910. The only record of the transfer of infection from

man to man is in a case reported by Harris in which a mother is believed to have contracted tularaemia through a prick of her thumb received while dressing the ulcer on her fly-bitten son.

(5) Animal bite: One case in Montana followed the bite of a coyote *(Canis lestes)*; another case in the same state followed the bite of a ground squirrel *(Citellus richardsoni)*; a case in Iowa followed the bite of a hog *(Sus scrofa domestica)*. Presumably the mouth parts of the coyote, ground squirrel, and hog were contaminated by infected rabbits which they had eaten, because dead rabbits were found near by, readily accessible.

TRANSMISSION AMONG WILD ANIMALS.

Ticks, lice and flies are believed to transmit the infection from rabbit to rabbit in nature, because they are efficient transmitters in the laboratory. There is the possibility also of transfer by nasal secretion and urine from rabbit to rabbit, these secretions having been found to contain the infection, and nasal washings from infected rabbits having caused the disease when dropped into the nares of healthy rabbits in the laboratory. Fleas and possibly lice are believed to transmit the infection from ground squirrel to ground squirrel.

SUSCEPTIBILITY.

Degrees of susceptibility are noted as follows: 1. High susceptibility in man, monkey, ground squirrel, rabbit, guinea pig, mouse, woodchuck, opossum, young coyote, pocket gopher, porcupine, chipmunk, musk rat, water rat of Europe, quail, grouse and Hungarian partridge. 2. Slight susceptibility in rat, cat, sheep and goat. 3. Nonsusceptibility in horse, cow, hog, dog, fox, pigeon, chicken and turkey.

1. Dermacentor andersoni.

(text-figures 1 ♂ and 2 ♀.)

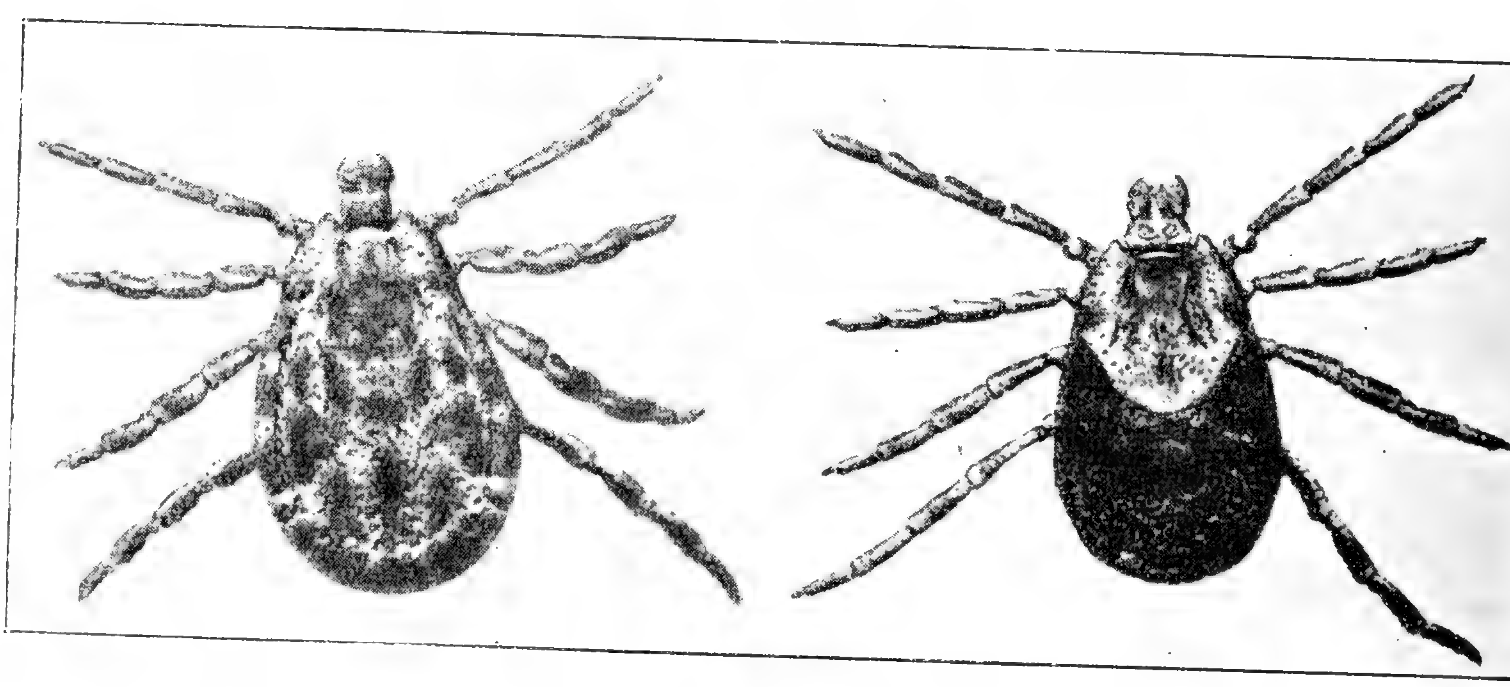


Fig. 1. Fig. 2.

Dermacentor andersoni ♂ ♀ (Prof. R. A. Cooley).

This tick plays a very important role in the transmission and maintenance of tularaemia. Fortunately, it is easly reared in the laboratory and

consequently it has served for extensive experimental studies. Its distribution in the United States is limited to the Rocky Mountain states.

Naturally infected ticks. — Parker and Spencer have reported: 1) that adult wood ticks of the species *Dermacentor andersoni* collected May 19, 1923 from vegetation in Montana and injected (16) into guinea pigs caused acute death of the pigs with typical lesions of tularaemia from which *Bacterium tularense* was isolated on culture medium; 2) that ticks collected in nature in Montana transmitted the infection to rabbits and guinea pigs on which infestation (20) took place May 5 to 8, 1925; 3) that numerous cases of tularaemia in man had occurred in Montana due to tick bite (18).

Laboratory infected ticks. — Parker and Spencer (16) (17) reported: 1) that nymphal ticks reared in the laboratory and infected as larvae by feeding on a tularaemia guinea pig caused acute death with typical lesions of tularaemia in a guinea pig on which they fed 247 days after the ingestion of infected blood by the antecedent larvae; 2) that adult ticks reared in the laboratory and infected as larvae caused typical tularaemia in a guinea pig on which they fed 199 days after ingestion of infected blood by the antecedent larvae; 3) that tularaemia was hereditarily transmitted by *Dermacentor andersoni* females to their eggs, larvae and nymphs, but not to the adults; nymphal infection was demonstrated 208 days after parent female engorgement. This is the first record of hereditary transmission of a known bacterium by an insect or arachnid.

Microscopic changes in ticks. — The foregoing observations and experiments led to a study by Francis (32) of the microscopic changes in ticks furnished by Parker from his laboratory in Montana, but infected in Washington, D. C. Ticks were studied only within 30 days after their first infective feed, in smears, cultures, and serial sections of adults infected as adults by feeding on infected guinea pigs. The result was a demonstration that *Dermacentor andersoni* is a true biological host of tularaemia — that it harbors the infection not only in its faeces but also in the epithelial cells of its digestive tract and Malpighian tubes, and in its coelomic fluid.

Method of infecting ticks. — Infection of ticks was accomplished in August, 1924, by feeding two lots of adults on guinea pigs which had been infected either by subcutaneous inoculation of a virulent culture of *Bacterium tularense* or by being rubbed on the abraded skin of the abdomen with the spleen of a guinea pig dead from tularaemia. The life of an infected guinea pig is three to five days, and bacteremia is greatest in its dying hours. Ticks were transferred in a tangled mass from a glass vial to a piece of coarse-meshed linen gauze, 4 inches square, and immediately covered with a brass gauze capule 1½ inches in diameter. The linen gauze was then drawn tightly around the wire capsule and tied with a string. The ticks, thus confined, were applied to a clipped area on the front of the thorax of an infected guinea pig, where they fed through the linen gauze. The capsule was held firmly against the skin of the pig by a band of adhesive tape 3 inches wide which encircled capsule and pig.

Ticks were applied to a guinea pig 24 hours after inoculation and were allowed to remain until the death of the pig. The capsule containing the ticks was then removed and applied to a second pig which had been

inoculated 24 hours previously and were again allowed to remain until the death of the pig. Ticks were in this way applied to a series of five or six infected pigs within a period of about three weeks in order to insure maximum infection.

Infection of coelomic fluid. — As ticks reached engorgement, their body fluid was examined in smears for the presence of *Bacterium tularense* preliminary to dissection. No tick was dissected until its body fluid showed organisms in a stained smear. On clipping the terminal joint of a leg with scissors, the body fluid welled up and was collected with a capillary pipette and transferred to a slide and stained. If no organisms were found, the tick was again applied to an infected pig. If organisms were found, the fluid was cultured and the tick was dissected, fixed, embedded, sectioned serially, and stained in Giemsa solution. One can usually predict by the color of the body fluid whether organisms will be found in smears, because normal body fluid is straw colored and clear, but infected coelomic fluid is distinctly turbid and milky in color and shows myriads of coccoidal and bacillary organisms (see text-fig. 3).

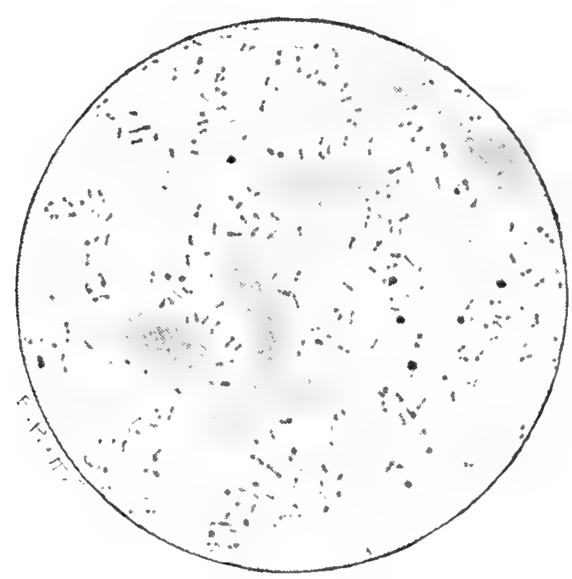


Fig. 3. — Smear of body fluid of leg of tick *Dermacentor andersoni* showing *Bacterium tularense*. (Original).

Cultures of coelomic fluid. — Pure cultures of *Bacterium tularense* were readily obtained by transfer of a drop of a milky body fluid to coagulated egg yolk medium by means of a capillary pipette. Growth became abundant after incubation at 37° for 24 hours. As a precaution against contamination while taking cultures of the body fluid, the terminal joint of the leg was first bathed with iodine, then clipped with sterile scissors and the escaping fluid was touched with the tip of a sterile capillary pipette, into which it entered freely, and was transferred to a culture tube.

Animal inoculations. — Guinea pigs inoculated subcutaneously with body fluid in which organisms were found always died acutely, manifesting the typical lesions of tularaemia. Guinea pigs inoculated with the loose, dried particles of tick faeces which accumulated quite abundantly in the wire capsule while ticks were feeding, died acutely and showed the typical lesions of tularaemia.

Pathological technique. — Only living ticks were dissected for serial sections and not those which seemed to die from the infection. During dissection, ticks were immobilized under a dissecting microscope on

a strip of zinc oxide adhesive plaster which was fixed to a block of wood, the outstretched legs being pressed into the adhesive by strokes of a warm dissecting needle (text-fig. 4). The dorsal chitin was grasped with a pair of

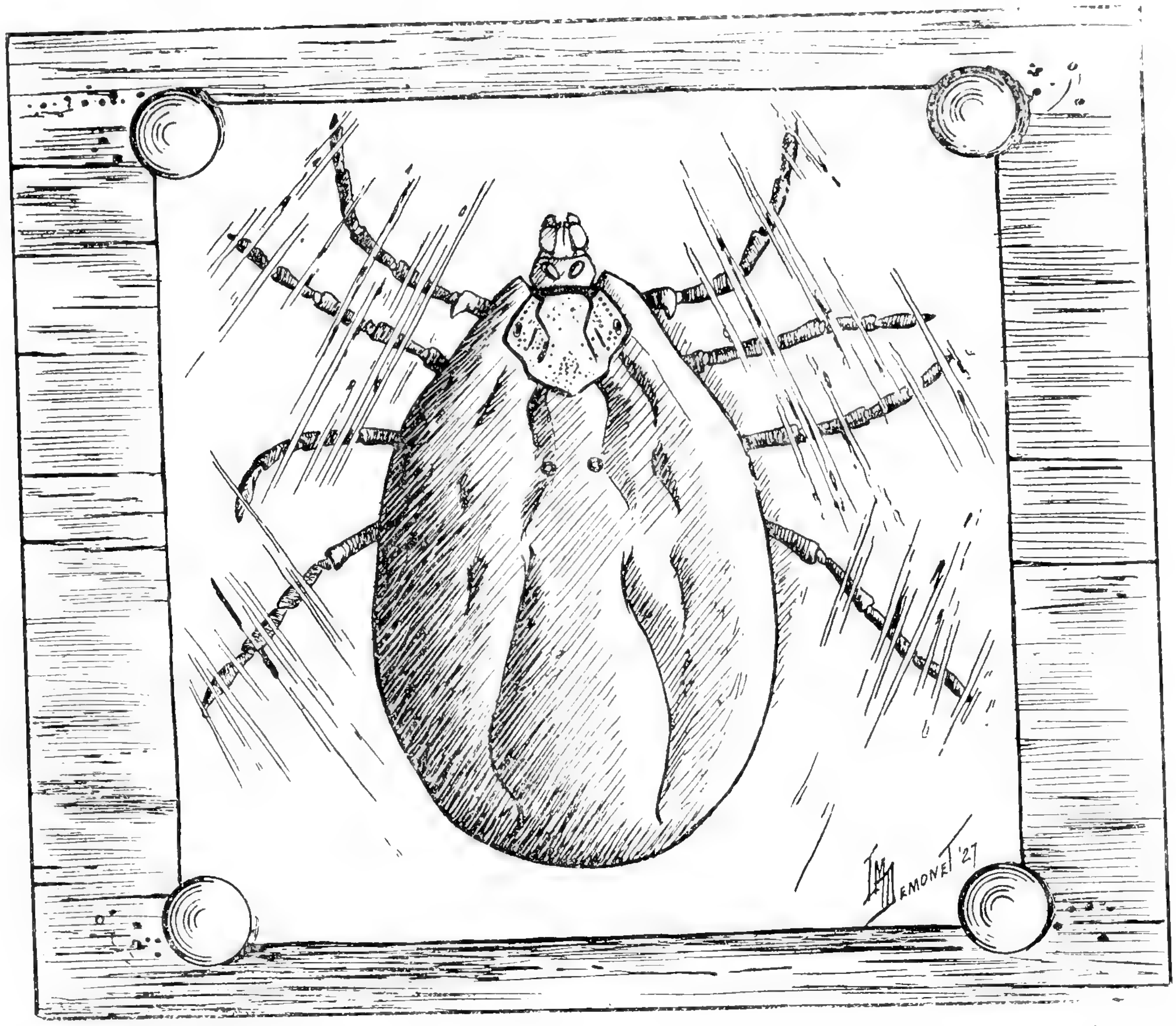


Fig. 4. — Method of immobilizing a tick during dissection. Adhesive plaster fastened to a block of wood with thumb tacks. Legs of tick pressed into adhesive by strokes of a warm needle.

strong forceps ground to a fine point, and was cut away with a cataract knife, the entire tick being bathed in a large drop of saline solution. The organs were then freed in a mass by dissection from the ventral chitin and fixed in Zenker's solution. The further steps of imbedding in paraffin, sectioning, and staining were carried out as recommended by Wolbach (33).

Microscopic changes. — The striking feature of the serial sections was the distention of the epithelial cells of the rectal sac, intestines, and Malpighian tubes with organisms forming blue-stained areas which instantly caught the eye under the 16 mm. objective.

Cellular invasion. — The epithelial cells of the rectal sac (text-fig. 5), of the lower intestine at its junction with the rectal sac, of the diverticulae of the intestine and of the Malpighian tubes, in the order of frequency named, were swollen and packed with organisms which were confined to the protoplasm of the cells and did not invade the cell nucleus. Between the invaded cells were normal epithelial cells. Occasionally there was a fusiform swelling of the gut wall, projecting toward the lumen and containing organisms; this indicated multiplication of the organisms in the wall itself. Occasionally a circular colony of organisms having the size and shape of a swollen epithelial cell was seen free in the lumen, as if the distended cell had ruptured and discharged its contents in a mass; this

would account for the infectiousness of the faeces. There was an absence of wide-spread distribution of free organisms in the lumen, thus indicating an absence of general multiplication of organisms in the contents of the intestine, rectal sac, and Malpighian tubes.

Absence of Organisms: — Organisms could not with certainty be identified in sections of the salivary glands, ovaries, eggs, male genitalia, heart, brain or muscles. Although the coelomic fluid was rich in organisms, the walls of the body cavity were so torn apart by dissection and washing as to preclude demonstration of organisms within the normal channels of the circulation.

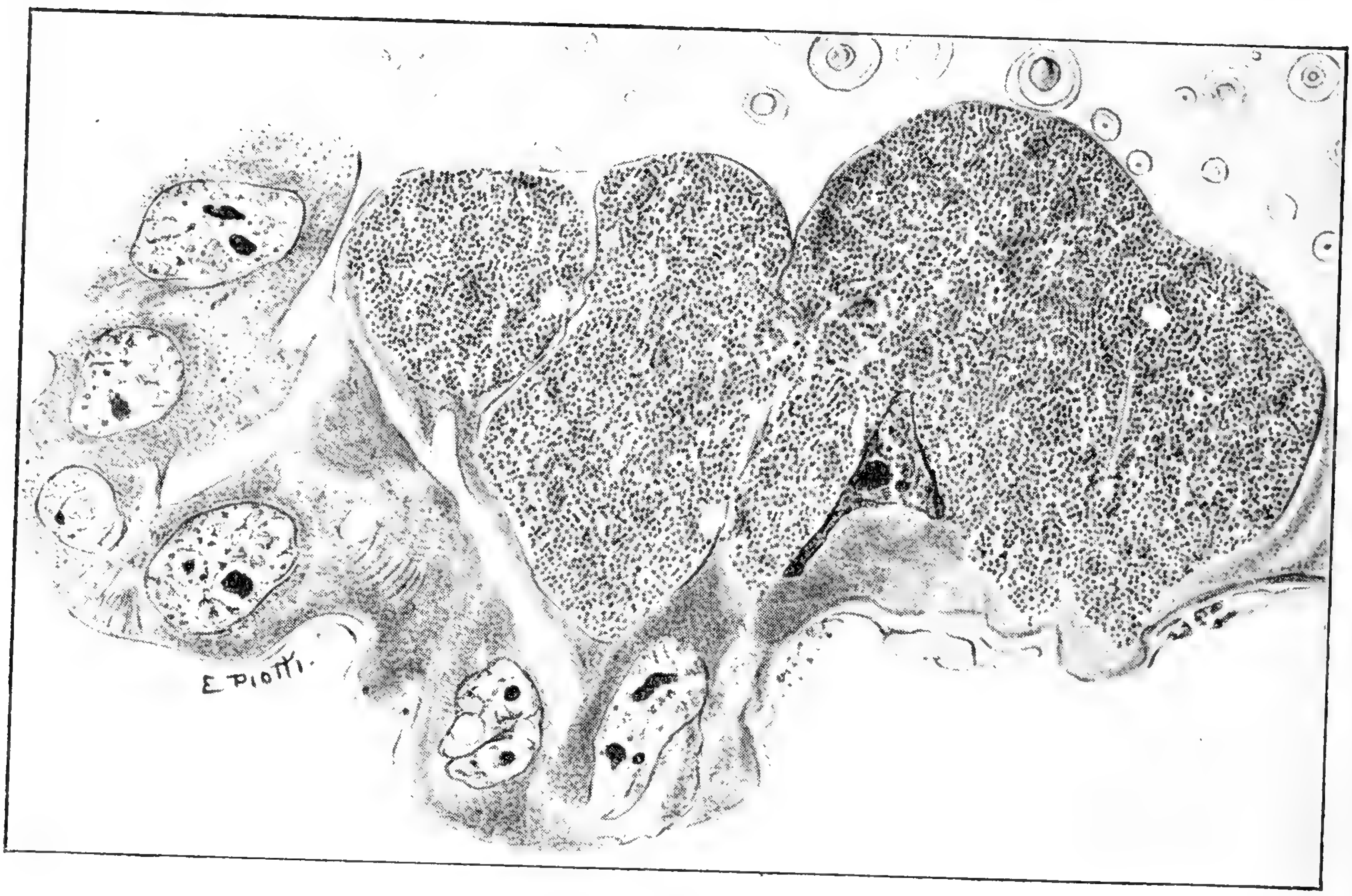


Fig. 5. — Section of rectal sac of tick *Dermacentor andersoni* showig epithelium distended with *Bacterium tularense*. (Original).

Method of transmission. — The absence of demonstrable organisms in the salivary glands and their constant presence in the faeces leads to the belief that transmission by tick bite is due to the mechanical entrance of faeces through the biting wound.

Another mode of infection of man by ticks, other than tick bite, very probably occurs through the penetration of the normal or injured skin by organisms found in the body fluid or excreta of ticks. Since infectious material readily passes through the normal skin of guinea pigs and rabbits, contamination of the human skin with fresh tick faeces or with the body fluid of injured ticks is a very probable mode of infection. Certainly the infection has been conveyed to the human conjunctiva by fingers which have crushed infected ticks, resulting in the oculoglandular type of infection.

2. *Dermacentor variabilis.*

Human cases of tularaemia have occurred in Southern United States in states in which *Dermacentor andersoni* is not found. Louisiana has reported seven cases with onset in February, April, July and October. Tennessee has reported five cases with onset in April, May, June and August. Texas has reported two cases with onset in April and July. Arkansas has reported six cases with onset in May, June and July. In none of these instances has the infecting tick been identified. *Dermacentor variabilis* and *Amblyomma americanum* have received consideration on account of the distribution of the cases and because both species not infrequently attack man and because both are three host ticks. The reports of Hooker, Bishopp and Wood (34) giving the host records and distribution of *Dermacentor variabilis* show that the larvae and nymphal forms of this species have been taken on rabbits. No laboratory experiments have been made to test the infectivity or power of transmission of *Dermacentor variabilis*, but consideration of the present data has suggested such experiments.

3. *Haemaphysalis leporis-palustris.*

This tick infests rabbits and birds, but seldom bites man. Rabbits in all parts of the United States are infested with it, so that doubtless it plays an important part in the natural maintenance of tularaemia. The number of experiments with this species has been small on account of the difficulty of rearing it under laboratory conditions. Parker (16) reported an experiment in which a larva which had been infected by feeding on an infected Belgian hare caused tularaemia by inoculation into a guinea pig 114 days after the infective larval feeding. No actual stage to stage experiments were done.

4. *Chrysops discalis.*

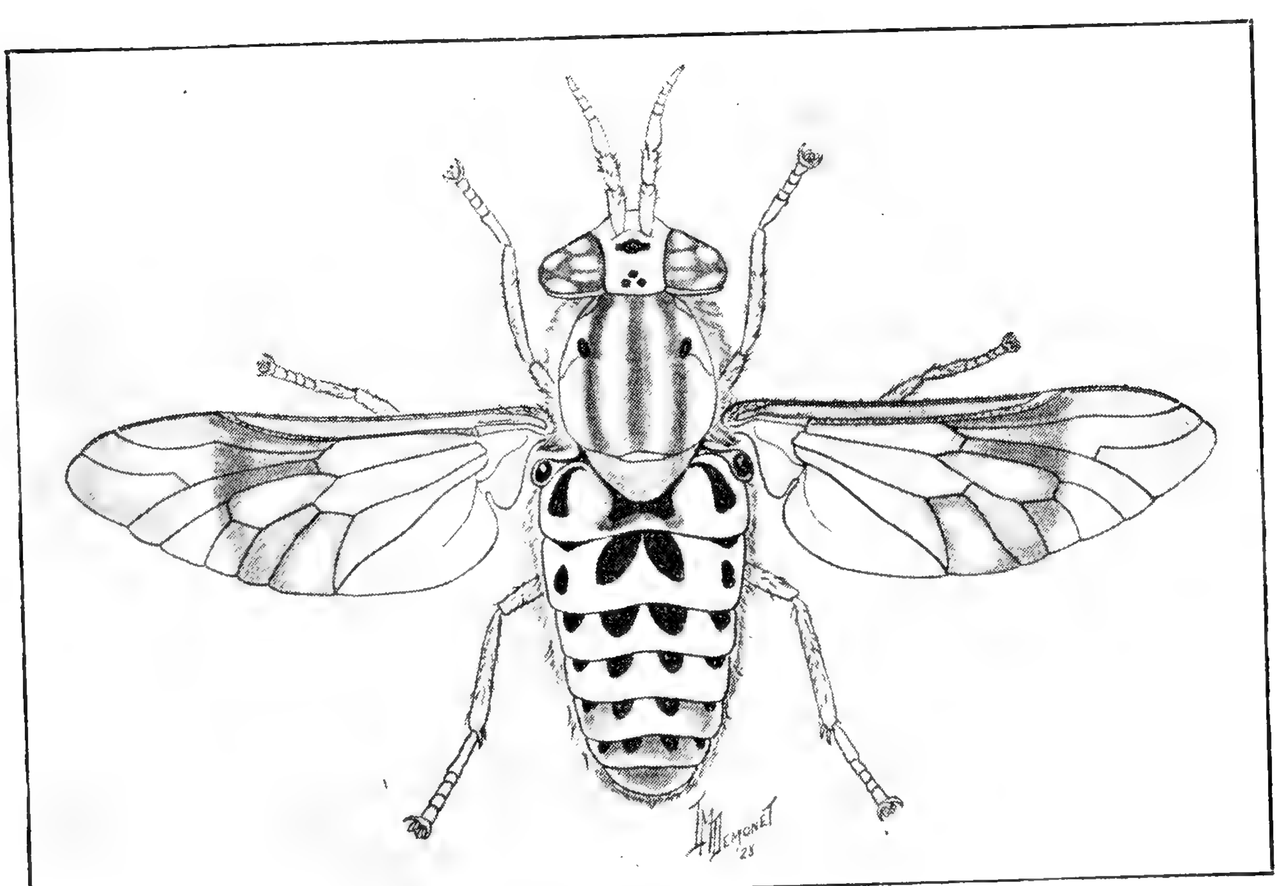


Fig. 6. — *Chrysops discalis* ♀. (Original).

The largest number of cases due to fly bite have been reported from Utah, but fly-bitten cases have also been reported from Wyoming, Idaho, Colorado, Nevada, Oregon and Montana. The list of states in which *Chrysops discalis* has been collected includes also Washington, California, and North Dakota, but human cases due to fly bite have not been reported from these states.

The findings of F r a n c i s (12) (13) and M a y n e (15) whose studies of "deer-fly fever" were made at Delta, Utah, in 1919 and 1920, may he summarized as follows:

E p i d e m i o l o g y. — There was the coincident presence in the community in June, July, and August of 1) fly-bitten human cases from which *Bacterium tularense* was isolated; 2) dead and dying jack-rabbits, from which *Bacterium tularense* was isolated; and 3) *Chrysops discalis,* which were found especially along the shores of small lakes, on horses and cows.

Proof of the agency of *Chrysops discalis* in transmission from rabbit to man might demand the collection of this species upon rabbits and the demonstration, by guinea pig inoculation, of the infection in flies taken in nature, but neither of these propositions was undertaken.

E x p e r i m e n t a l d a t a. — In a field laboratory the following observations were made: 1) *Chrysops discalis* collected upon horses, and confined within lantern globes which were closed with coarse gauze, transmitted *Bacterium tularense* in eleven experiments from infected guinea pigs and tame rabbits to healthy guinea pigs and tame rabbits. 2) Interrupted feeding was employed in four successful transmission experiments in which the time which elapsed between biting the infected animal and biting the healthy animal was only a few seconds and the number of flies employed in the experiments was one, six, eleven and sixteen, respectively. 3) The longest interval to elapse in a successful transmission experiment between biting the infected and the healthy animals was four days. 4) In order to determine how long *Chrysops discalis* may remain infected, infected flies were kept at an average temperature of 15 to 20° C, and on each succeeding day, up to 15 days, one or more flies were killed, their wings and legs were discarded, and the body, after being crushed in a mortar and suspended in physiological salt solution, was injected subcutaneously into a guinea pig. The longest time that such a fly remained infected was 14 days. The next longest was 10 days and the next was 8 days, below which almost all flies were found to be still infected. 5) The microscopic changes in infected flies were not studied.

M e t h o d o f T r a n s m i s s i o n. — The mode of transmission was assumed to be mechanical — by the introduction of infected material into the biting wound by the contaminated proboscis.

C o l l e c t i o n o f F l i e s. — A horse, a boy, and an ice-cream freezer constitute the most important equipment for collecting flies in large numbers for experimental purposes. The horse, after being ridden at high speed through the brush near the border of a lake, is brought to a stand-still; his flies are then covered with glass tubes and transferred to lantern globes, which are then stored in the can of a 10-gallon ice-cream freezer, packed with ice. On return to the laboratory the lantern globes are transferred to a box cooled to 15 to 20° C. Flies chilled by resting on a block of ice remain quiet in natural position for a photograph.

5. *Stomoxys calcitrans.*

Wayson (35) using *Stomoxys calcitrans* and employing forced interrupted feeding (8 bites of one or two flies on an infected guinea pig being alternated by 8 bites on a healthy guinea pig) transmitted the infection in two experiments, the whole process being carried out within one hour's time. Flies were not found to remain infected longer than 24 hours after the infecting meal.

6. *Haemodipsus ventricosus* Denny.

This species was collected from jack rabbits in Utah and was found in great numbers on laboratory rabbits at Washington, D. C. Since this species is an efficient transmitter among rabbits in the laboratory, it is assumed to play the same role in nature. We obtained no record of its having bitten man.

The forerunner which led to our louse experiments was the fact observed in the laboratory that 43 healthy rabbits, placed in contact with tularaemia rabbits, died of that disease between Feb. 3 and May 16, 1921. The possibility existed that transmission in these cases was due to the known infectivity of nasal secretions and urine, but this possibility was eliminated in the following louse experiments.

Francis and Lake (36) in May, June, and July, 1921, conducted experiments in the Hygienic Laboratory, Washington, D. C., which may be summarized as follows: (1) Lice clinging to the butts of hairs which were pulled from the lumbar and sacral regions of rabbits dead of tularaemia, were transferred to the hair of 16 rabbits comprising series I, eleven of which died with typical tularaemia. (2) Lice were similarly transferred from dead rabbits of the first series to series II consisting of seven healthy rabbits, 6 of which died of tularaemia. (3) Lice were similarly transferred from dead rabbits of the second series to a third series of four healthy rabbits, 3 of which died of tularaemia. (4) The intervals which elapsed between infestation of healthy rabbits and their deaths varied from 8 to 26 days. The intervals between removal of lice from infected rabbits and their application to healthy rabbits were in all successful experiments not over three hours, with three exceptions, in which the intervals were 2, 3 and 3 days, respectively.

7. *Polyplax serratus* Burm.

This louse was collected in large numbers upon white mice reared in the Hygienic Laboratory, but of 56 wild gray mice caught in snap traps in various parts of the building at night and examined the next morning, only one harbored a single louse specimen and this was the rat louse, *Polyplax spinulosa* Burm. Ten mites, *Liponyssus isabellinus*, collected from the hair of a white mouse dead of tularaemia and injected into a white mouse caused its death from tularaemia. We have no evidence that this species transmits the infection in nature or that it bites man.

Contact of infected white mice with 24 healthy mice in an aquarium jar resulted in the death of all from tularaemia by the 15th day. Under similar circumstances of contact, 26 white mice contracted the infection and died within a period of 25 days. In the latter instance, after the death of the last mouse in the jar and the removal of all dead mice therefrom, the

jar was left undisturbed for eight days. At the expiration of this time eight healthy mice were introduced into the jar, but they remained well.

Cannibalism, lice, mites and the known infectivity of mouse urine having been possible factors of infection in the contact experiments, transmission experiments by lice alone were undertaken in July, 1921, by Francis and Lake (37), the results of which were as follows (1) Lice removed from the hair of white mice dead of tularaemia were transferred to the hair of eleven healty white mice comprising series I, nine of which died of tularaemia. (2) Lice were similarly transferred from dead mice of the first series to series II consisting of 6 healthy mice, 3 of which died of tularaemia. (3) The number of lice transferred to each mouse of series I varied from 10 to 43, and the number employed in series II varied from 5 to 25. The time which elapsed between the deaths of infected mice and the transfer of their lice to healthy mice varied from a few minutes to 18 hours.

Three lots of 25 lice each which were removed from 3 mice and kept on hair in Petri dishes at room temperature in August were all dead by the end of 48 hours.

8. *Ceratophyllus acutus.**)

From 1910 until the present time a few instances of infection with *Bacterium tularense* have been encountered each year among ground squirrels shot in various parts of California and sent to the United States Public Health Service Laboratory in San Francisco for examination as part of the general anti-plague campaign. The number of squirrels found infected with tularaemia has remained small, probably because the squirrel flea is a feeble transmitter. No human case of tularaemia has been reported due to contact with the California ground squirrel or with its flea, *Ceratophyllus acutus*.

McCoy (2) and McCoy and Chapin (4) obtained successful transmission by the squirrel flea *C. acutus* by injection of infected fleas, by contact of squirrels in the presence of fleas, and by transfer of fleas from squirrel to squirrel. A more detailed statement of their transmission experiments is as follows: (1) Injection into guinea pigs of *C. acutus*, removed from recently dead squirrels or guinea pigs, reproduced the infection when the interval between removal and injection was 24 hours or less, but failed when the interval was longer than 24 hours. Injection into guinea pigs of the rat flea, *Cerat. fasciatus*, removed from recently dead guinea pigs, transmitted the infection when the interval between removal and injection was 48 hours, or less, but failed when the interval was longer than 48 hours. (2) Contact of an inoculated squirrel and two healthy squirrels in a cage in which 100 fleas *(C. acutus)* were liberated resulted in the death of both contacts, one having the bubo in the inguinal region and the other in the axilla. (3) Contact of an inoculated squirrel and two healthy squirrels in a cage in which 500 fleas *(C. acutus)* were liberated resulted in the death of both contacts, one having the bubo in the neck and the other in the mesentery. (The location of the buboes indicates that transmission was probably by ingestion.) (4) Transfer of 100 *C. acutus* from an inoculated dead squirrel to a clean cage containing a healthy squirrel resulted in the death of the latter,

*) An earlier name is *C. montanus* Baker.—Editor.

the bubo being in the neck. Several failures resulted in similar attempts to transmit the infection by the transfer of squirrel fleas from squirrel to squirrel. Failure resulted in all attempts to transmit the infection from guinea pig to guinea pig by transfer of squirrel fleas or rat fleas.

9. *Cimex lectularius.*

There is no report of the transmission of tularaemia to man by bedbugs, nor is there any suspicion that bedbugs transmit the infection in nature among animals. Under experimental conditions in the laboratory bedbugs have transmitted the infection from mouse to mouse.

Transmission by bugs. — In experiments reported by Francis and Lake (38) it was noted that forced interruption of a bug's meal of blood on an infected mouse conduced to the immediate completion of that meal on a healthy mouse. The shorter the period of interruption, the greater the likelihood of transmission. When the interruption was for only a few seconds, transmission was successful in all attempts (five) and was due to the mechanical transfer of infection by a grossly contaminated proboscis.

Transmission by bugs which first fed to engorgement on infected mice and a few days later fed to engorgement on the tails of healthy mice was successful in only three of our twenty-three attempts; the intervals which elapsed between the biting of the infected mice and the biting of the three healthy mice were 7, 15, and 71 days, respectively; the number of bugs employed in the three transmissions were groups of 28, 24, and 14, respectively; the exact parts played by bites and by faeces in the three transmissions are impossible of determination, because the mouse tails became freely covered by bug faeces during each biting experiment, which lasted one hour.

Duration of infection in bugs. — In the experiments reported by Francis (32) infection was demonstrated in bugs up to the forty-seventh day, when the experiments terminated. In experiments reported by Francis and Lake (37) tularaemia caused acute death of a mouse which ate a bug which had been infected 226 days previously and caused acute death of a guinea pig which was injected with fresh faeces of bugs which had been infected 250 days previously. The indications from the experimental inoculations and from the histopathology are that bugs remain infected throughout their lives. Hereditary transmission of infection through the egg was not tested.

Method of transmission. — In spite of the long duration of infection in the bug and the wide distribution of infection in its body, transmission by feeding (other than interrupted feeding) was quite infrequent and was probably due to the mechanical entrance of infected faeces through the biting wound.

Microscopic changes. — Infection in bedbugs was studied in smears, cultures, and serial sections of 30 bugs experimentally infected by feeding on infected white mice and sectioned at various intervals up to 47 days after the first infective feed.

The normal coelomic fluid obtained from a leg was clear and straw-colored, but an infected fluid was cloudy or milky in color, showed *Bacterium tularense* in smears, yielded a pure culture of the organism on culture me-

dium and killed a guinea pig acutely, producing the typical lesions of tularaemia.

Serial sections of infected bugs showed multiplication of organisms in the fresh blood contents of the anterior portion of the mid-gut, heavy infection of the epithelial cells of the posterior portion of the mid-gut, and occasional infection of the Malpighian tubes.

Anterior portion of mid-gut: Groups or colonies of blue-stained organisms were readily visible with the 16 mm. objective, distributed throughout the unaltered blood contents of the expanded cardia or anterior portion of the mid-gut, but no invasion of the epithelial cells of the wall was noted in that portion, although organisms were seen in contact with the wall.

Posterior portion of mid-gut: The most striking feature in bugs was the invasion of the epithelial cells of the posterior portion of the mid-gut with organisms which caused the swollen, infected cells to stand out pro-

Fig. 7.
Section of gut of bug *Cimex lectularius* showing epithelium distended with *Bacterium tularense.* (Original).

minently in blue outlines under the 16 mm. objective. With the 2 mm. objective the cell protoplasm was seen packed with blue-stained organisms which did not invade the cell nucleus (text-fig. 7). Between infected cells were normal cells. In cross-section of a restricted portion of the gut the projection of the swollen cells toward the lumen almost caused its obliteration. In cross-section of an expanded portion of the gut infected cells, with or without a nucleus, were seen free in the lumen as if they had been given off from the wall or as if a cell had ruptured and discharged its contents in a mass having the outline of a cell. The gut wall was invaded with organisms causing fusiform blue-stained swellings to project toward the lumen. Wide-spread distribution of the organisms in the gut contents, such as one would expect if the contents were acting as a culture medium, was not seen. The cells at the constricted junction of gut and rectum were usually heavily infected, but definite infection of the cells of the rectum was not seen.

Malpighian tubes: — Cells distended with organisms were frequently seen. As in the gut, they were readily visible with the 16 mm. objective.

Absence of infection: — *Bacterium tularense* was not seen in the oesophagus, salivary apparatus, reproductive organs, brain or muscles.

Literature.

1. Francis, Edward: History of Tularaemia; De Lamar Lectures, Johns Hopkins University, Series 1926—27.
2. McCoy, G. W.: A Plague-Like Disease of Rodents; in Public Health Bull. 43, *U. S. P. H. S.*, April, 1911.
3. id. and Chapin, C. W.: *Bacterium tularense* the Cause of a Plague-Like Disease of Rodents; ibid., Bull. 53, January 1912, p. 21.
4. id.: Further Observations on a Plague-Like Disease of Rodents with a Preliminary Note on the Causative Agent, *Bacterium tularense;* in J. Infect. Dis. 10, pp. 61—72 (Jan.), 1912.
5. Pearse, R. A.: Insect Bites; in Northwest. Medicine, March, 1911.
6. Vail, D. T.: Bacillus tularense Infection of the Eye; in Ophth. Rec. 23, p. 487, 1914.
7. Wherry, W. B. and Lamb, B. H.: Infection of Man with *Bacterium tularense;* in J. Infect. Dis. 15, pp. 331—340, 1914.
8. iid.: Discovery of *Bacterium tularense* in Wild Rabbits, and the Danger of its Transfer to Man; in J. A. M. A. 63, p. 2041, (Dec. 5), 1914.
9. Wherry, W. B.: A New Bacterial Disease of Rodents Transmissible to Man; in Pub. Health Rep. 29, pp. 3387—3390, 1914.
10. Martin, Ancil: Tularaemia Infection of Conjunctiva (Case Report); Southwestern Medicine 9, pp. 232 and 237 (June) 1925.
11. id.: Tularaemia; ibid., 10, p. 249, (June) 1926.
12. Francis, Edward: Deer-fly fever: A disease of Man of Hitherto Unknown Etiology; in Publ. Health Rep. 34, pp. 2061—2062 (Sept. 12) 1919.
13. id.: The Occurrence of Tularaemia in Nature, as a Disease of Man; ibid. Rep. 36, pp. 1731—1738 (July 29), 1921.
14. id.: Tularaemia, a New Disease of Man; in J. A. M. A. 78, pp. 1015—1018 (Apr. 8), 1922.
15. id., and Mayne, Bruce: Experimental Transmission of Tularaemia by Flies of the Species *Chrysops discalis;* in Pub. Health Rep. 36, pp. 1738—1746 (July 29) 1921.
16. Parker, R. R., Spencer, R. R. and Francis, Edward: Tularaemia Infection in Ticks of the Species *Dermacentor andersoni* Stiles in the Bitter Root Valley, Montana; ibid. 39, pp. 1057—1073 (May 9) 1924.
17. Parker, R. R. and Spencer, R. R.: Hereditary Transmission of Tularaemia Infection by the Wood Tick, *Dermacentor andersoni* Stiles; ibid. 41, pp. 1403—1407 (July 9) 1926.

18. id.: Tularaemia and its Occurrence in Montana; in Sixth Biennial Report, Montana State Board of Entomology, 1925—1926, pp. 30—41.
19. Parker, R.R. and Francis, Edward: Susceptibility of the Coyote *(Canis lestes)* to Tularaemia; in Pub. Health Rep. 41, pp. 1407—1410 (July 9) 1926.
20. Parker, R.R. and Spencer, R.R.: Six Additional Cases of Laboratory Infection of Tularaemia in Man; ibid. 41, p. 1341 (July 2) 1926.
21. Ohara, Hachiro: cited by Francis, Edward, and Moore, Dunlop: Identity of Ohara's Disease and Tularaemia; in J. A. M. A. 86, p. 1329 (May 1) 1926.
22. Francis, Edward: Tularaemia; ibid. 84, pp. 1243—1250 (Apr. 25) 1925.
23. id. and Callender, G. R.: Tularaemia, the Microscopic Changes of the Lesions in Man; in Arch. Path. 3, pp. 577—607 (April) 1927.
24. Francis, Edward: Symptoms, Diagnosis, and Pathology of Tularaemia; in J. A. M. A. 91, pp. 1150—1160, 1928.
25. id.: A Summary of present knowledge of Tularaemia, Harvey Lectures, series 1927—1928; in Medicine 7, pp. 411—432 (Dec.), 1928.
26. Parker, R. R. and Dade, J. S.: Tularaemia in Sheep in Nature, Pub. Health Rep. 44: 126—130 (Jan. 18) 1929.
27. Green, R. G. and Wade, E. M.: A Natural Infection of quail by *Bacterium tularense;* Proc. Soc. Exp. Bio. and Med., 26, pp. 626—627, 1929.
28. Revue de Microbiologie, d'Epidémiologie et de Parasitologie, t. VII, No. 3, pp. 340—344, 1928, Saratov.
29. Francis, Edward: Tularaemia in the Washington, D. C., Market; in *Pub. Health Rep.* 38, pp. 1391—1396 (June 22) 1923; Mil. Surgeon 53, p. 164 (Aug.) 1923.
30. Dieter, L. V. and Rhodes, Bernice: Tularaemia in Wild Rats; in J. Infect. Dis. 38, pp. 541—546, 1926.
31. Perry, J. C.: Tularaemia Among Meadow Mice *(Microtus californicus aestuarinus)* in California; in Pub. Health Rep. 43, pp. 260—263 (Feb. 3) 1928.
32. Francis, Edward: Microscopic Changes of Tularaemia in the Tick *Dermacentor andersoni* and the Bedbug, *Cimex lectularius;* ibid. 42, pp. 2763—7272 (Nov. 11) 1927.
33. Wolbach, S. B.: Studies of Rocky Mountain Spotted Fever; in J. Med. Res. 41, pp. 1—197, 1919.
34. Hooker, W. A., Bishopp, F. C. and Wood, H. P.: The Life History and Bionomics of some North American Ticks; in Bull. 106, Bur. of Ent. U. S. Dept. of Agr., 1912, p. 178.
35. Wayson, N. E.: Plague and Plague-Like Disease: A Report on their Transmission by *Stomoxys calcitrans* and *Musca domestica;* in Pub. Health Rep. 29, pp. 3390—3393, 1914.
36. Francis, Edward, and Lake, G. C. Experimental Transmission of Tularaemia in Rabbits by the Rabbit Louse, *Haemodipsus ventricosus* (Denny); ibid. 36, pp. 1747—1753 (July 29) 1921.
37. iid.: Transmission of Tularaemia by the Mouse Louse, *Polyplax serratus* Burm.; ibid. 37, pp. 96—101 (Jan. 20) 1922.
38. iid.: Transmission of Tularaemia by the Bedbug, *Cimex lectularius;* ibid. 37, pp. 83—95 (Jan. 20) 1922.

Environmental Factors and Mosquito Breeding.

Professor Willem Rudolfs,*)

Dept. of Water Supplies and Sewage Disposal, Rutgers University, New Brunswick, N. J.

(With a map and a diagram.)

Anti-mosquito work began in New Jersey in the year 1900 with certain local efforts and with Dr. John B. Smith's study of life history and habits of the mosquito species characteristic of that state. From this beginning the work has expanded; at first slowly, then with increasing rapidity, until at the present time it covers the entire Atlantic coastal strip, and in the northeastern part of the state the upland as well. The counties in which anti-mosquito work covers all of the territory are Hudson, Essex, Union and Bergen. In Passaic anti-mosquito work covers only the southern half which is heavily populated. In Middlesex, Monmouth, Ocean, Burlington, Atlantic and Cape May the primary effort is devoted to the control of the salt marsh species. In Morris Country, which does not touch the sea coast and has no salt marsh, anti-mosquito work is just beginning.

In this territory, exclusive of Morris Country, live more than two and one-half millions of people as well as a numerous population of summer visitors.

A very considerable measure of protection from mosquitoes is afforded to this population. This protection ranges from slight, in parts where the work is beginning, to very nearly perfect, where the work is completely handled (table 1).

While the results of present methods of mosquito control are gratifying and the per capita cost is low (11 cents in 1927), there is always a chance that further knowledge may greatly increase the efficiency of anti-mosquito work. For this reason investigations, of which the following is an account, together with others are being constantly authorized and financed.

Effect of Drainage.

We know fairly well what can be accomplished by drainage and oiling in combating mosquito breeding. Not much is known of the changes of the territory brought about by drainage. It is conceivable that the soil solution is changed by the extraction of water and subsequently the type of plant growth is changed. A change of plant growth might further alter the soil physically and chemically by the difference in plant requirements, root growth and character of their decomposition. Drained areas subject to seasonal or tidal flooding may then form a different habitat for microscopic

*) Paper of the Journal Series, New Jersey Agricultural Experiment Station, Dept. of Entomology.

growth used as food for mosquito larvae and finally the type of breeding changed.

Some years ago a brief study was made, comparing meadows which had been diked in with another part of the same area which had been left undiked so that tide water covered it at intervals. The effect of this treatment was very pronounced on the vegetation. The diked and undiked meadows were originally similar, but the former had been closed to salt water for about 10 years. The vegetation in the undiked area was typical salt meadow grass, whereas the growth on the diked meadow consisted mainly of weeds, mostly golden rod and dog weed.

Samples of the soil were taken from these places by cutting a sod about 12 inches wide and long and 24 inches deep, and slicing off sections at 6, 12 and 18 inches. The soil samples were analyzed for chlorides, carbonates, sulfates, moisture, volatile matter content and reaction. The results obtained are given in table 2.

The remarkable change in soil reaction from slight alkalinity in the open meadow to considerable acidity in the closed meadow would in itself give a clue for the change in vegetation. The moisture content in the top layer of the open meadow was considerably higher than in the top layer of the closed meadow. This would mean that the water holding power of the layer was far greater than in the closed one, in spite of the fact that the organic matter content (roots, decaying plants) was greater in the dry meadow. Clay and silt was apparently removed by drainage, causing a physical change in the soil structure. The salt content in the open meadow was naturally greater than in the closed one. On the basis of chlorides the open meadow had in the 18 inches an average of 8.2 % NaCl and but 0.58% was found in the closed meadow.

It is small wonder that the ultimate conditions produced by drainage were so different. The chemical and physical conditions of the soil changed, followed by changes in vegetation and finally a change in the type of mosquito breeding.

Effect of General Environment. — Swamps.

As an example of the general effect of environment upon mosquito breeding the following is given. Mosquitoes appeared to be absent in a cedar swamp area apparently well suited for breeding, while along the edges and nearby marshes heavy breeding occurred. The drainage in the swamp was good except at the head of the streams and bordering parts of their courses. The soil was sand to sandy loom, with peat and partially decayed organic material on top. The native forest consisted mainly of cedars, pine and oaks. The undergrowth was abundant, except in some places where the cedar and pine stand was so thick that almost no light could penetrate. The undergrowth was mainly huckleberry, cranberry, laurel, bracken, greenbrier, staggerbush, wintergreen, sandwort and holly. Fern was abundant in depressions and the lower imperfectly drained situations, and sphagnum moss was plentiful in the swamps. Two creeks drained the region (text-fig. 1).

Samples of the water were taken in the middle of the swamp, following the streams out into the open salt marshes. The water was analyzed and the microscopic animal and plant life determined.

The condensed results are given in tables 3 and 4. From the analyses it would appear that the acidity of the water was mainly due to humic

acids. Only small amounts of sulfates were found. Chlorides appeared as soon as the creeks were subject to tidewaters.

The flora and fauna was almost absent in the middle of the swamp, increased when the edges were reached (both in type and numbers).

No mosquito breeding was found in the interior of the swamp. The food supply was apparently too scant. As soon as light could penetrate the

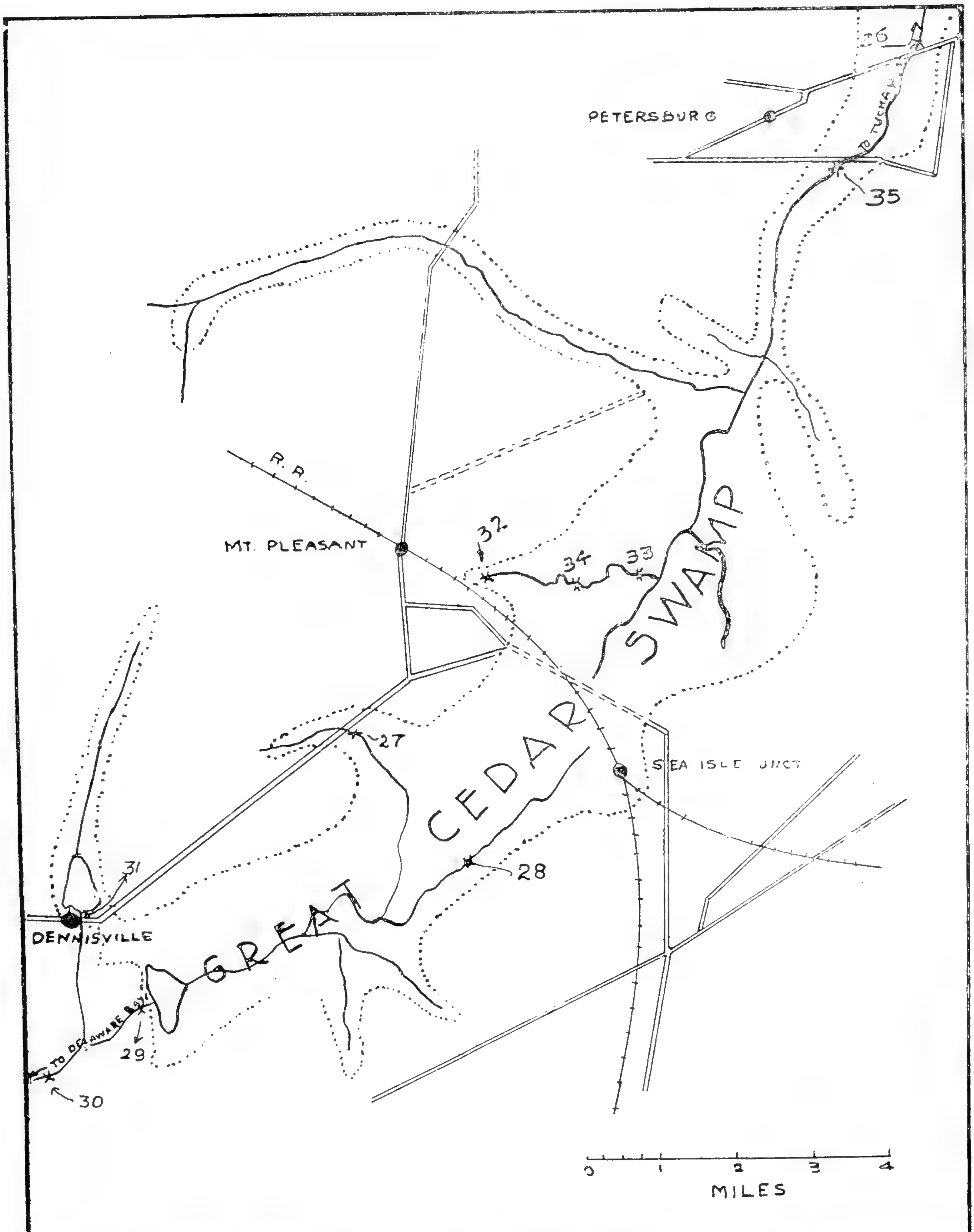


Fig. 1. — Great Cedar Swamp. Numbers at sampling places correspond to numbers in tables.

thick forest, undergrowth and animal and plant life in the water increased. With the increase of food supply mosquito breeding increased.

Another example of the general effect of environment is furnished by clay pits. These large pits are dug for clay used in ceramic work. Samples of water were taken from old abandoned pits and new working pits. The results are given in tables 5 and 6. The reaction varied in these pits from 3.0 to 7.6. No breeding occurred in any of these pits, due presumably to the relatively large amounts of Al and Fe sulfates and chlorides, for, when strong cultures of protozoa and bacteria were added to the waters, *Culex pipiens* larvae remained alive for 8 days in numbers 22 and 26. Microscopic examination after 8 days showed that the food supply was practically exhausted. The reaction had but slightly changed, namely in No. 22 from 7.5 to 7.4 and in No. 26 from pH 4.7 to 4.8.

Reaction of Water and Breeding.

Into a number of water samples, collected from different areas, *Culex pipiens* larvae were introduced and their behavior recorded. The samples were analyzed for their chemical constituents, and plants and animals present determined. The pH range was from 3.0 to 7.6. In some cases the larvae died soon after being introduced; in other cases they remained alive for 8 to 10 days. In one case the larvae remained alive for 20 days, but none emerged, although finally two larvae out of 60 pupated. Those which survived remained stunted. Microscopic examination showed that the food supply was apparently sufficient to keep them alive, but not enough to allow growth. In several instances death of the larvae could be traced to exhaustion of food supply.

To similar water, collected from a number of places, *Culex* larvae were introduced and concentrated mixtures of protozoa, fungi and bacteria were added as food supply. The larvae were introduced without adding water and were able to live and subsist on the food added. Their death rate was not greater than larvae placed in rain water.

In another series the reaction of the water was artifically changed with either $CaCO_3$, Ca $(OH)_2$ or H_2SO_4. Those waters with higher pH values were treated with H_2SO_4 to bring about an increase in hydrogen-ion concentration and those with higher H-ions concentrations treated with $CaCO_3$ and $Ca(OH)_2$ to raise the pH to 7.6. Larvae were introduced and left standing for 24 hours. At the end of this period nearly all larvae had died. Most of the larvae which succumbed had died within the first 4 hours. The sudden changes of reaction seemed to be fatal to the larvae. In order to check this up a quantity of rain water in which an abundance of *Culex* larvae were present, and another quantity of water taken from a polluted ditch breeding heavily was treated with the same chemicals, but in such a way that the reaction was adjusted gradually over a period of 7 to 8 hours. About 500 larvae of all sizes were present in the rain water, which had a pH value of 4.4. A quantity of the water was taken out and put into a bottle and 10 larvae introduced. This bottle was left standing untouched. The reaction of the remainder of the water was changed to pH 4.6 and again a quantity taken out with 10 larvae and placed in a container to be left standing. After 30 minutes the water was further adjusted to pH 4.9, a quantity of water and some larvae taken out and again placed aside. This

procedure was repeated about every 30 minutes until the reaction of the water reached a pH value of 8.0. The rain water was adjusted from 4.4 to 7.1 with $CaCO_3$ and from 7.1 to 8.0 with $Ca(OH)_2$.

A similar procedure was followed with the polluted ditch water, adjustments made with H_2SO_4 from pH 7.7 to 4.3 and the resulting series of cultures left standing in the laboratory.

The results obtained are set forth in table 7. It is evident that within considerable limits the gradual change of reaction did not appreciably influence the death rate of the larvae. There is no doubt that some of the larvae were injured by handling or mechanically when the water was stirred after each adjustment. This might partially explain the increase in killed larvae present in the adjusted rain water. The kill noticed at lower pH values, obtained in the adjusted polluted water with H_2SO_4, is possibly due to the penetration of the acid rather than the reaction of the medium. However, even in this case but little if any effect was noticed in changing the reaction from 7.7 to 5.2.

Composition of Water and Breeding.

During several years analyses of the waters in two pools have been made by us in an effort to find a possible relation between specific breeding and the chemical composition of the water, or if this failed, to eliminate these so-called factors from the picture. The two pools under consideration were (1) where supposedly no breeding would take place and (2) a typical woodland pool where continuous breeding of *Aëdes canadensis* occurred. Pool No. 1, which according to records had not bred mosquitoes for several years, was practically round shaped, fifty feet in diameter and varied from 3 to 5 feet in depth. The pond was shaded by red oaks and pin oaks on three sides, but in the afternoon was exposed to the sun. In mid-summer the edges of the pond were covered with duck week and grasses and it was then about half filled with water lillies. Pool No. 2 was situated in the middle of woodland, surrounded by white and red maple, oak and a few birch and beech trees, some brush and a dense growth of cinnamon ferns. At the bottom of the pool was a mat of decaying leaves similar to pool No. 1. It was irrigular in shape, fairly shallow, ranging from 12 to 18 inches deep and about 75 feet long by 40 feet wide. During the summer the pool was for about 95% shaded at noon time, while at other times of the day the water surface was even less exposed to the sum.

Pool No. 1 contained water throughout the breeding season (April-October), whereas pool No. 2 went dry during a period in mid-summer.

Procedure.

Samples were collected last year in duplicate at intervals of 14 days (former years every week), brought to the laboratory and analyzed for total acidity, CO_2, HCO_3, CO_3, Cl, SO_4, NH_3, albuminoid N, total N, carbon, Al, Fe and pH values determined. The total numbers of bacteria, numbers and species of protozoa, algae and fungi counted, temperature records kept and the extent of mosquito breeding estimated. The chemical analyses were made according to the official water analyses methods of the A. P. H. A. Enumeration of plankton was made by Dr. James B.

Lackey, Research Zoologist. Estimates of mosquito breeding were made by counting the number of larvae in one liter of water taken in a number of dips at different places in the pools.

Results.

Assuming that the optimum reaction for breeding would be in the neighborhood of neutrality rather than in an acid or alkaline medium, from the data secured it would seem that the reaction of the water had little if anything to do with the breeding, because breeding occurred when the reaction was farthest away from neutrality and nearest to it, and no breeding also occurred under both conditions. If total acidity, carbon dioxide, bicarbonates, chlorides, and sulfates are factors in breeding, they did not seem to exert much influence in these cases, because breeding occurred with either high or low total acidity, with 40 p. p. m. CO_2 and with 4, with 5 p. p. m. chlorides and 75 and with 2 and 112 p. p. m. sulfates. If any of these factors influence breeding, it does not seem with the quantities present. It has been held by some investigators that ammonia present in very small quantities is inhibitory to breeding. This might be the case for certain species of malaria mosquitoes, although we have found breeding of culicines in liquid containing from 15 to 120 p. p. m. free ammonia.

It does not appear that albuminoid nitrogen present in quantities ranging from 0.4 to 9.6 p. p. m. affected breeding, because in some instances there was breeding with the smallest and in others with the largest quantities. We have found breeding of *C. pipiens* in liquid containing 42 p. p. m. albuminoid nitrogen.

Total nitrogen and total carbon determinations were made to find the ratios between carbon and nitrogen in the water. It could be conceivable that the relation between carbon and nitrogen present in the water affected the growth and possibly the numbers of the larvae. If the adults had laid their eggs in water with an unbalanced carbon nitrogen ratio, the larvae might remain stunted, even if the eggs hatched. That the carbon nitrogen ratio was not a limiting factor is illustrated in table 8.

Food supply.

We have pointed out before that there is a direct relation between the number of microscopic animals and plants with msoquito breeding. A few examples may suffice to illustrate this point.

Sample 2. Protozoa fairly abundant, few algae, mosquito breeding. Guts of larvae contained: Euglena, Algal spores, Trachelomonas, fungal remains. The percentage of Trachelomonas found in guts of two larvae was far above what would be expected from the numbers in the samples, but the other organisms agreed with the water.

Sample 7. There were enough Difflugia at the bottom and enough small flagellates at the top of the water to provide food; however, animal life was distinctly scarce; plant life practically lacking. Sparce mosquito breeding.

Sample 8. Practically no protozoa or algae present, certainly not enough for larval food. No breeding.

As soon as the numbers of microscopic animals and plants increased in the pool which was devoid of breeding until the early fall, larvae appeared and the density of breeding increased with the food supply.

Bacteria.

An effort was made to determine whether the total numbers of bacteria were possibly directly responsible for the difference in breeding in the two pools. The results obtained showed that the numbers of bacteria in the water where no breeding occurred was nearly always higher than in the water with breeding. This might mean that: (1) the protozoa and other animals in the water where larvae were present lived partially on the bacteria and thereby kept the numbers down; (2) the bacteria were of a type unsuitable for protozoa and mosquito larvae; (3) these bacteria were producing substances toxic to themselves and to protozoa and (or) larvae; (4) the bacteria present in the water where breeding occurred produced specific substances which stimulated the growth of protozoa and algae and subsequently of the larvae.

In order to throw some light upon some of these questions two sets of experiments were carried out. First, an attempt was made to determine whether the food supply in the water was sufficient for the bacteria to grow and multiply, and to determine whether substances were produced toxic to the bacteria. Secondly, an experiment was conducted with the muck and partially decayed vegetable matter present at the bottom of the pools to find out whether there was a difference in the rate of decomposition, and the substances produced during the course of decomposition, which could stimulate the growth of plankton and thereby influence the density of breeding, or possibly stimulate oviposition or more likely the hatching of eggs.

Bacterial Food Supply.

Water was collected from the two different pools, brought to the laboratory and mixed in certain proportions with liquid present in a sewage disposal tank known to contain considerable quantities of suitable bacterial food and large numbers of bacteria. If toxic substances were present in the water the numbers of bacteria should have been greatly reduced either with sterilized or non sterile water. The figures given in table 9 show that no such reduction in bacteria took place and it might be concluded that no substances were present which were toxic to the bacteria. The regular increase in bacteria when more water was added shows also that it was not a question of absence of bacterial food.

Material from Bottom of Pools.

A mixture of muck and partially decayed vegetable matter present at the bottom of the pools was brought to the laboratory for further study. Composition of the material was as follows:

Pool	Moisture %	Vol. matter %	Total N %
No breeding	78.1	37.3	1.1
Breeding	85.7	79.7	1.9

Sufficient amouts of the substances were put into bottles so that the quantities of volatile matter were about the same in both instances, namely 81.7 grams from the non breeding pool and 85.4 grams from the other. The materials were incubated at about 20° C and the total acidity, organic acids, pH values, ammonia and gas production determined at intervals. The results obtained are graphically shown in figure 2.

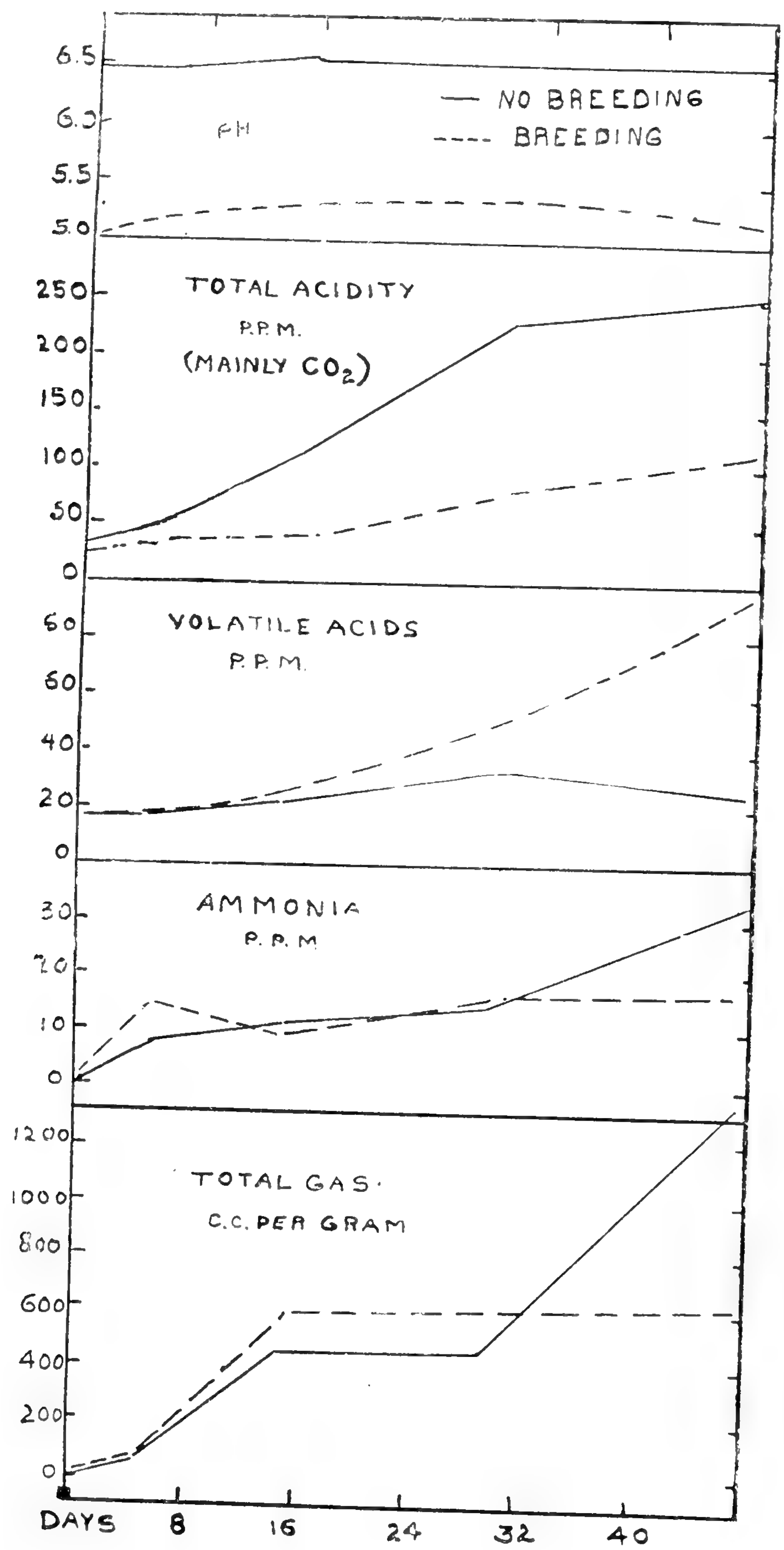


Fig. 2. — Differences in decomposition of materials from bottom of pools.

Difference in Decomposition.

The curves show a remarkable difference in decomposition of the two kinds of materials. The material from the breeding pool produced persist-

ently less total acidity, but far greater quantities of organic acids than the material from the non breeding pool.

It has been found in our laboratory that small quantities of organic acids added to decomposing material stimulates the growth and abundance of protozoa enormously. It is therefore quite possible that the available food supply in this pool is directly related to the type of decomposition taking place at the bottom.

The low pH values encountered throughout the year seem to be directly related to the amounts of organic acids formed in the processes of decomposition.

It seems clear, therefore, that the reaction of the water as such is not necessarily an indication of the abundance of food supply and subsequent breeding of mosquitoes. It is even possible that under certain circumstances a comparatively high acid concentration as indicated by low pH values is far more favorable to breeding than a low acid concentration. This is directly opposite to the views held by some other workers.

The quantities of ammonia produced by the decomposing material from the breeding pool were fairly constant, whereas the amounts of ammonia produced from the other pool increased with the time of incubation. Another interesting thing is that after 47 days of incubation the material from the non breeding pool produced more than twice as much gas as the material from the breeding pool. The composition of the gas from the former pool was fairly typical for ordinary marsh gas. It contained 23.5% carbon dioxide, 62.2% methane and 13.2% nitrogen.

A comparison of total acidity and carbon dioxide present in the water during the summer with the total acidity found in the decomposing material shows that results are similar. The breeding pool contained always more total acidity and CO_2 than the water of the non breeding pool.

From all indications it appears now that specific substances either present in the water or produced by the decomposition of vegetable matter may be responsible for the growth of micro-organisms and subsequently for the breeding of mosquitoes. It is a well known fact that different species of mosquitoes prefer or at least breed in different types of water. It is conceivable, therefore, that specific substances present in the water, probably of an organic nature, are responsible for the breeding of specific species of mosquitoes.

The question arises at once what is the nature of the specific substances. The fact that the ammonia content of the decomposing material of the non breeding pool increased persistently, whereas it remained constant in the material from the breeding pool would indicate that it is not a question of nitrogenous decomposition products. Ordinarily there would be no ammonia accumulation if rapid decomposition of carbonaceous substances took place, because the organisms would assimilate the ammonia formed, with possible higher total nitrogen contents. Moreover, we have found in our laboratory that, when gas production is high, organic acids are low, because the decomposition processes go to completion. This would indicate that the type of decomposition is different in the two pools. It is also interesting to note that the water of the breeding pool was always

browner, due to humid acids, which accumulate, than the water of the non breeding pool. This would lead us to conclude that it is the type of decomposition of carbonaceous material which is an important factor in the breeding of mosquitoes; especially if we keep in mind that certain types of organic acids stimulate the growth of protozoa which serve as food for the larvae, and that certain quantities of humic acid are not detrimental to breeding of mosquitoes.

A number of investigators have reported that ordinarily certain species of mosquitoes breed together and that these "associations" are fairly limited. This might mean that specific species are commonly attracted to water containing certain kind of substances. If this is true the problem is more complex than was thought originally, but at the same time simpler to solve, because the number of specific substances would be larger, and if one is found it might furnish a clue for the others.

Summary.

From the work conducted during the last five years it is evident that gross environmental factors affect the breeding of mosquitoes, while a number of individual factors have no effect.

Whenever environmental factors were such that insufficient food supply resulted, no breeding occurred.

Larvae were killed within 24 hours when the reaction of the water was changed suddenly, but a gradual change of the reaction of the water within natural limits did not appreciably effect the death rate or breeding of larvae.

Aëdes canadensis and *Culex pipiens* larvae were present in pools either with high or low total acidity, free carbon dioxide, chlorides, sulfates, carbonates, free ammonia and albuminoid ammonia. Changes in the carbon nitrogen ratios of the water did not seem to affect breeding.

Breeding occurred with high and low numbers of bacteria, but whenever the amounts of diatoms, protozoa, fungi, etc., were low, breeding was absent.

There was a marked difference in decomposition of vegetable material obtained from the bottoms of different pools. It is possible that specific substances produced by the decomposition of vegetable matter may be responsible for the growth of micro-organisms and subsequently for the breeding of mosquitoes.

Literature.

1. Rudolfs, W. — 1924. Mosquito breeding in specific places; in Journ. Parasitology 11, pp. 79—83.
2. — — 1925. The food of mosquito larvae; in Proc. N. J. Mosq. Ext. Assoc. p. 25—33.
3. — — 1926. Investigations of mosquito problems carried on during the past year; ibid.
4. — — 1928. Contributions to the cause of mosquito breeding in specific places; ibid.
5. — — 1928. The composition of water and mosquito breeding; in Amer. Journ. of Hygiene.

Table 1.

Figures for 10 counties doing mosquito work in New Jersey (1927).

	Area in acres	Feet- new ditches cut		Feet- ditches cleaned		Oil used in gallons
		before 1927	1927	by hand	machine	
Salt marsh .	184,020	27,463,060	1,015,900	3,139,350		45,159
Upland . .	1,604,780	3,273,130	324,235	1,408,685		164,811
Total . . .	1,788,800	30,736,190	1,340,135	4,548,135	4,366,030	209,970

Population 3,818,280
Net valuations $ 4,794,642,900
Acres drained by dikes, tide gates and pumps 32,477.

Table 2.

Analyses of soil in open and closed meadows.

Open meadows.

Depth	Reaction pH	Moisture %	Vol. Matter %	Chlorides %	Sulfates %	Carbonates %
6"	7.9	80.7	35.1	5.53	0.60	.083
12"	7.4	68.0	31.0	5.49	1.02	.075
18"	7.3	72.6	27.4	4.80	1.56	.041
Closed meadows.						
6"	5.6	31.7	46.6	0.37	1.00	.004
12"	5.5	68.7	24.7	0.33	2.54	.020
18"	5.3	71.0	31.8	0.42	1.13	.007

Table 3.

Chemical analyses of water.

No. *)	Reaction	Ca and Mg.	Fe_2O_3	Al_2O_3	SO_4	Cl	NO_3	CO_2	Humic acids (precip.)	Color †) (yellow)
	pH	ppm.	ppm.	ppm.	ppm.	ppm.	0	ppm.		
27	4.8	0	0	0	0	0	0	4.4	+++	5
28	5.1	0	0	14	4	170	0	1.8	++	1
29	6.8	0	0	190	19	tr.	0	2.2	+	0
30	7.3	tr.	120	580	70	3900	0	4.4	+	1
31	7.3	tr.	tr.	320	60	3910	0	2.8	+?	1
32	5.4	tr.	0	tr.	0	tr.	0	0.9	+	1
33	6.5	0	0	tr.	40	2960	0	1.8	+	2
34	6.3	tr.	350	tr.	50	262	0	1.8	+++	6
35	7.2	tr.	0	1840	70	8660	0	4.4	++	3
36	7.4	tr.	tr.	1720	100	9720	0	4.2	+	2

*) Numbers indicate sampling places on the map.
†) Highest score is 10.

Table 4.

Animal and plant life in natural waters from Great Cedar Swamp region.

No.	Plants *)	Animals *)
27	None	Mesodinium Amphisia
28	Practically nothing	None
29	Green algae Desmids Micrasteris Leptozosma	A few dinoflagellates
30	None	Aspidisca Phacus
51	Diatoms — few	Tintinopsis common Small flagellates
32	None	A very few small flaggellates
33	Diatoms Pleurosigma Cyclotella Suriella Basillaria Melosira (life scarce)	Small flagellates Tintinopsis A few unidentified ciliates Actinosphaerium Rotifers
34	Diatoms (life scarce)	Shelled Rhizopods Cyphoderia Arcella Difflugia Trinema Euglypha Flatworms Rotifers Small flagellates Actinophrys Acanthocystis Vorticella Dysteria Pleuronema Mesodinium
35	Diatoms — Brown algae Chatomorpha — Green algae Merismopedia — Blue green algae (life fairly abundant)	Mesodinium Spirostomum Centropyxis Coleps

*) All samples looked very barren to the eye. They were therefore centrifuged and the enumeration made from the organisms found in the centrifuged liquid.

No.	Plants	Animals
36	Diatoms Pleurosigma Cyclotella Suriella Blue green algae Lyngbya (life abundant)	Small flagellates Tintinopsis (very small form) Mesodinium Gymnodinium Halteria Ceratium Euglena (very unusual form) Unknown Heliozoon Clathrulina Nemertine worms Small Copepod

Table 5.

Chemical analyses of water in clay pits.

No.	pH	Ca Mg.	Fe_2O_3	Al_2O_3	SO_4	Cl	NO_3	CO_2	Color (yellow)
		ppm.	ppm.	ppm.	ppm.	ppm.	ppm.	ppm.	
20	7.6	tr.	220	330	250	780	0	4.4	0
21	4.6	0	0	640	90	280	0	1.8	0
22	7 5	tr.	180	450	170	180	0	0.9	0
23	7.2	tr.	210	860	270	130	0	1.8	1
24	3.2	0	920	4000	2270	250	10	47.5	5
25	3.0	0	0	1520		130	4	22.0	0
26	4.7	tr.	0	210	480	140	0	8.8	0

Table 6.

Animal and plant life in clay pits.

No.	Pit	Plants	Animals
20	Old	Brown algae Diatoms Green algae Dictyosphaerium (life negligible)	Protozoa Small flagellates Euglena Halteria Carchesium
21	Medium	Brown algae Diatoms-many genera Green algae Mongeotia Desmids — 4 small genera Blue green algae Merismopedia (life fairly abundant)	Protozoa Dinobryon Small flagellates Dinoflagellates — 2 genera Euglena Epiclintes Rotifers Daphnia

No.	Pit	Plants	Animals
22	Old	Brown algae Diatoms Green algae Scenodesmus Desmids-Closterium (very little life)	Protozoa Oxyarhis Trachelomonas Euglena, viridis, spirogyra Halteria Rotifers Daphnia
23	New	None	Few small flagellates
24	New	Unknown fungus	Protozoa Minute flagellates Unknown ciliate Small green flagellates Euglena
25	New	Practically devoid of life, save for a few minute flagellates and an occasional Rotifer.	
26	Medium	Diatoms — small ones, about 4 genera, abundant	Protozoa Small Euglena Oxytrichia Several other ciliates Nassula Amoeba

Table 7.

Results with reaction adjusted waters.

Time	Rain water				Polluted water			
	pH	larvae used	killed 24 hours	killed 72 hours	pH	larvae used	killed 24 hours	killed 72 hours
9.00	4.4	10	0	1	7.7	10	0	2
9.30	4.6	10	0	2	7.5	11	0	1
10.00	4.9	10	0	1	7.2	13	0	1
10.30	5.1	12	1	1	7.0	10	0	2
11.00	5.4	11	0	3	6.7	12	2	2
11.30	5.8	13	1	2	6.5	11	1	2
12.00	6.2	10	1	1	6.2	14	3	3
12.30	6.6	14	3	3	6.0	10	2	3
1.00	6.9	10	2	2	5.8	12	2	4
1.30	7.1	12	1	3	5.7	11	2	2
2.00	7.4	13	4	5	5.6	12	3	3
2.30	7.7	12	3	7	5.2	14	3	4
3.00	8.0	10	2	5	4.8	12	10	11
3.30					4.6	12	10	10
4.00					4.3	11	11	11

Table 8.
Carbon-nitrogen ratios in waters.

Sample No.	C/N	Remarks
1	4.8	No breeding
2	4.95	Breeding
3	4.1	Breeding
4	4.1	No breeding
8	3.0	No breeding
23	2.85	Breeding
24	2.9	Breeding

Table 9.
Effect of food supply and toxic substances.

No.	Mixture	Bacteria per cc. original material	Bacteria per cc. water used.
1	Tank liquid (pH 7 1)	18,100,000	N. 27500
2	1 cc. N. sterilized water 10 cc. T. L.	16,610,000	B. 1700
3	10 cc. N. ,, ,, ,, ,, ,, ,,	48,200,000	
4	1 cc. B. ,, ,, ,, ,, ,, ,,	14,960,000	
5	10 cc. B. ,, ,, ,, ,, ,, ,,	40,000,000	
6	Tank liquid (pH 6.8)	68,000,000	N. 44000
7	1 cc. N. sterilized water 10 cc. T. L.	49,500,000	B. 18000
8	10 cc. N. ,, ,, ,, ,, ,, ,,	36,400,000	
10	10 cc. B. ,, ,, ,, ,, ,, ,,	62,800,000	
11	Tank liquid (pH 6.8)	68,000,000	N. 44000
13	1 cc. N. not sterilized 10 cc. T. L.	65,200,000	B. 18000
15	10 cc. B. ,, ,, 10 cc. T. L.	148,000,000	

N. = No breeding.
B. = Breeding.
T. L. = Tank liquid.

The Department of Apiculture of the Moscow District Agricultural Experimental Station and its Work on the Role of the Honey Bee in Pollination of Agricultural Plants. *)

A. F. Gubin, Director,
Moscow District Agricultural Station, Moscow, U. S. S. R.

The apicultural station is situated at a distance of 27 kilometers South-west of Moscow and represents an independent department of the Moscow Agriculture Station. The staff consists of 4 permanent persons (A. F. Gubin being director) and 3—5 temporary summer collaborators. The station has two apiaries with 126 hives. The subsidiary apiary is devoted to investigation on hybridization of the Caucasian and Middle Russian bee. There are 2 laboratories, a biological and a chemical one, 8 pavillions for control hives, recording scales, different subsidiary workshops. The main problems which are being worked out are problems of physics and chemistry of the honey and the wax, technology of the products of beekeeping, particularly the problems of the wax-rendering from old combs, and the relation of bees to agriculture plants. The present report has the purpose to give the information concerning the results obtained during the last 2—3 years. The first question to be discussed is the question of the existence of red clover bees. This question, so vividly discussed in the beginning of this century on the pages of the leading beekeeping magazines in the United States of America, was in Russia shortly before the world war a subject of very extensive investigation on farms of one of the members of the royal family. The leader of this investigation and its practical applications on a very large scale was I. N. Klingen, an agriculturist with a very broad biological education. His conclusion supported by a more recent opinion of a well known plant breader, Lisitzin, is that the successful fertilization of the red clover depends on two circumstances:

1. The absence at the moment of the blooming of the red clover of any competition with other nectar secreting plants;
2. Cultivation of long tongued Caucasian bees.

Klingen was an ardent amateur of grey Caucasian bees, and several hundreds of Caucasian colonies were cultivated under his direction on the above mentioned estates. One of the papers published in connection with Klingen's campaign is that of Chochlow (1916) accomplished in the laboratory of the Zoological Museum of the University of Moscow. This author assumes that only bees with a tongue length over 6.69 mm

*) Read and prepared for press by W. W. Alpatov, University of Moscow.

are able to collect nectar from the flowers of red clover. His assumption was based on the fact that the average length of the tube of the corolla in red clover is equal to 8.34 mm and the level of the nectar is 1 mm above the bottom of the flower. According to the observation on the level of the nectar in the flowers of the red clover a very high percentage of flowers contains nectar standing even below the level of the ovary. It seems that the requirements of Chochlov for a successful nectar gathering are too rigorous. Special attention was devoted to develop an exact method of measurement of red clover flowers. The scheme of measurement has been described by A. F. Gubin (in 1928, Opitnaja Paseca, May-June pp. 257—263). Only freshly collected flowers gave irreproachable measurements. Different fixing fluids like formaline or alkohol contract very much the normal length of the flowers. A special investigation has shown that the plunging of the bees head into the tube of the red clover flowers is equal to 1.1 mm. Therefore the working capacity of the honey bee in nectar collecting is equal to the tongue length plus 1.1 mm. According to the measurements obtained by different authors and by ourselves the average length of the tube part of the flower of the red clover is between 9 and 10 mm, substracting 1.1 mm from this length we get the length (7.9 to 8.9 mm) which the bees ought to have in order to be able to collect nectar down to the bottom of the tube. It was shown that the capillary tube which is formed between the walls of the corolla and the pistil and sometimes of the 10 th stamen rises the level of the nectar above the normal height.

There are different ways in the adaptation of the clover and the abilities of the bees in nectar gathering, Mowing always results in a reduction of the tube length. In 1926 the difference between the average for the control and mown clover was statistically considerable ($R = 10.2$), in the experiments of the follwing year not very considerable ($R = 2.4$).

The testing of the specially selected Linghard's clover shows a difference from the control clover equal to 0.97 mm, the Linghard's clover having shorter tubes. The difference is statistically significant ($R = 20.86$). A survey of 10,000 bushes of clover on the fields of the plant breading department of the Moscow Experimental Station gave 5 bushes with a length of the tubes from 5 to 7 mm. Beside that there have been found individual plants with rudimentary tubules. These plants have a very queer appearance, the corolla not projecting from the calyx.

Another side of the above discussed problem is the investigation of working activity of different races of bees on different agricultural plants and particularly on red clover. A biometrical investigation of the tongue length of the bees taken from the hives of the apiary and those collected on red clover shows a coincidence of the location of the summits for Caucasian bees taken from the hives and collected on red clover and a shifting to the right of the summit of the variation curve for Moscow bees collected on clover in comparison with the curve based on measurement of bees taken directly from the hives. This means that at the moment when the bees were caught only longer tongued Moscow bees went to work on clover.

The following table gives the information that the average of the tongues of bees working on different plants is quite different. It must

be stated that the apiary of the Experimental Station contained Middle Russian and Caucasian bees.

Plant, Date of collecting	Average length of tongue in millimeters
Red clover 20. 6. — 6. 8. 1926 7.	6 37 ± .015
Fireweed 16., 17., 18. 7. 1927	6.24 ± .013
Wetch 14, 15, 16., 18. 7. 1927	6.52 ± .014
Red clover (mass visits) 16., 18. 7.	6 22 ± .013
" " 2., 18. 6	6 22 ± .015
" " 11.—26. 8.	6.30 ± .015
White " 4., 8. 7.	6.12 ± .012
Swedish clover 12—18 7.	6.14 ± .011
Bees robbing other hives during the inspection	6 67 ± .030
Bees caught in the laboratory.	6.64 ± .010

The very high average of the tongue length of bees collected on wetch indicates that the bees working on this plant belonged almost entirely to the Caucasian race. This fact gives us the right to call the Caucasian bees wetch rather than red clover bees.

A conclusion bearing upon practical beekeeping is this: it might be important — in order to attain complete utilization of the nectar secretion of the given locality — to keep different bee races in the apiary. There is probably a certain analogy between this conclusion and the advice of agronomy concerning the stabilizing of crops by the use of mixtures of seeds belonging to different varieties of a given agricultural plant.

Another branch of this work was devoted to the comparative study of the activity of honey bees and bumble bees in pollination of different agricultural plants. It was found that the number of bees visiting flowers shows pronounced decline about noon time, which is probably correlated with a decrease of nectar secretion. The honey bee starts its daily work earlier in the morning than the bumble bees, but on the other hand finishes the work earlier in the evening.

On normal red clover fields the bumble bees represented only 8.4% of the whole number of insects (bees and bumble bees), while on mown red clover with a delayed bloom the percentage of bumble bees was 45.8%. This diffence is due to the decrease of the number of bees and the increase in the number of bumble bees.

Comparing the activity of the honey bees and the bumble bees, we find that the latter visit about twice as many red clover flowers in a unit of time. The honey bees work faster in the middle of the day, i. e., they fly faster from one flower to another. It is unlikely that this correlates with temperature changes of the air. It is much more probable that it is due to the reduction of the nectar secretion about noon time. An attempt was made to find the relationship between the number of visited flowers and the number of those which contained seeds, i. e. were fertilized. For the clover of normal growth the figures expressing the percentages of visited flowers and of flowers containing seeds are almost the same (48.3% and 56.4%). On the other hand, the mown clover with a delayed bloom gave 15.9% flowers visited by insects and 69.1% containing seeds. This discrepancy which we cannot as yet explain shows the insufficiency

of our knowledge of the problem of red clover pollination (for instance the role of selffertilization).

In the study of nectarial secretion special attention was paid to the percentage of water and sugar in the nectar, and it was found that both these components are very closely correlated with climatic factors. The percentage of water in nectar is influenced by the humidity of the air and the soil, the first factor influencing the rate of transpiration, the second the comsumption of the water by the plant. The percentage of sugar up to the moment of full bloom is positively correlated with the average temperature of the air, after the moment of the full bloom the correlation seems to become negative. The explanation of this phenomenon seems to be the following.

Two processes are responsible for the amount of sugar in the nectar: assimilation and respiration. The first determines the accumulation of sugar, the second has a decreasing influence on it. Before the moment of full bloom the process of assimilation dominates and therefore the temperature influencing assimilation is positively correlated with sugar content. After the moment of highest bloom the respiration begins to prevail and being influenced by temperature results in a negative correlation between the percentage of sugar and the variation in the temperature of the air.

Very important facts concerning the technique of biometrical investigations on bees have been discovered during the work on variation of the tongues. It was found that the bee tongue shows a pronounced decrease in length if treated with 70° alcohol, caustic potash (KOH) and other chemicals. The tongue loses in some cases 7.4% of the original length. A special investigation has shown that other parts of the exosceleton of the honey bee are also subject to a more or less pronounced reduction in length. For instance, the loss after a twenty minute boiling in 5% solution of KOH is equal to 3.82% of the length of the ligula, a 1.50% of the mentum, 6.31% of the submentum, 4.44% of head, and 5.13% of the first joint of the tarsus of the hind legs. In order to have comparable results special precautions have to be taken in regard to a uniform scheme of preserving and measuring the bees.

Present Status of Methods and Policy of Controlling Insects Injurious to Agriculture and Forestry in U. S. S. R.

A. P. Adrianov, Department of Agriculture, Moscow, U. S. S. R.

The vast territory of the Soviet Union, the exceptional variety of natural and economic conditions of the country, and the presence of a large number of species of injurious insects create considerable difficulties for the organization in the U. S. S. R. of protective measures against these pests.

The thorough description of the harmful entomological fauna, the determination of the various species, the study of their distribution, ecology, and economic significance and the working out of rational methods of combating them — all these demand considerable work for many years to come. However, we have no reason to question the undoubted success of plant protection work during the past ten years.

In enumerating the present status of plant protection against injurious insects, we shall consider the following most important phases:

I. Network of institutions for the protection of plants.

II. Number of specialists employed in applied entomology.

III. Extent of practical measures for the control of injurious insects, and the results obtained by scientific research in applied entomology.

IV. Publications on applied entomology.

V. Financial and other material expenditures in connection with this work.

VI. Basic principles underlying the organization of plant protection measures and a dicussion of the problems in applied entomology which confront us.

I. NETWORK OF INSTITUTIONS FOR THE PROTECTION OF PLANTS.

Even the oldest institutions for the protection of plants cannot count many years since their organization. The former Central Experiment Institution — the Entomological Bureau of the Scientific Committee of the Department of Agriculture, now known as The Division of Applied Entomology of the State Institute of Experimental Agronomy — was founded in 1894. The first local institution, the Kiev Entomological Station, was established in 1904. In the next period of twelve years twenty-two entomological institutions were established. This network of twenty-three local institutions covered the territory of the Russian Empire of that time very unevenly. Thus there was no institution of any kind for the protection of plants in the Far East, Siberia, the Ural region, Kirghiz region, the Volga region (except Astrakhan), nor in any of the Northern regions of European Russia.

Since the organization of the Soviet Union, however, we note a rapid growth of entomological institutions and the establishment of additional ones in all the regions of the U. S. S. R.

At the present time we have the following chain of institutions for the protection of plants:

1. In the Russian Socialist Federated Soviet Republic, all the work of plant protection is centralized in the Bureau for the Protection of Plants of the People's Commissariat of Agriculture. There are also the following central research institutions under the auspices of the Commissariat of Agriculture:

a) Division of Applied Entomology of the State Institute of Experimental Agronomy.

b) Research laboratory for the study of insecticides, fungicides and apparatus used in plant control work.

c) Entomological Division of the Central Forestry Experiment Station.

The local Stations of Plant Protection in the Russian Socialist Soviet Republic (which is now one of the component parts of the Union of S. S. R.) are usually the same institutions engaged in entomological and phytopathological research and control work.

At present, the network of plant protection stations in the R. S. F. S. R. which are supported by the central government is made up of five regional stations, with thirteen branches, twenty-one provincial and nine stations with five substations in the autonomous republics, in all fifty-three institutions. Besides these, there are four stations financed by local governments. Most of the provincial and district agricultural organizations also employ plant protection specialists.

In addition to the above-mentioned plant protection stations there are four agricultural experiment stations that do research work through their divisions of entomology.

Besides all of the above institutions under the Commissariat of Agriculture, there are attached to the faculties of the agricultural colleges two stations of entomology which are under the Commissariat of Education.

Finally the work in systematic entomology is carried on by divisions of the Zoological Museum of the Academy of Science of the U. S. S. R.

2. The Ukrainian Soviet Socialist Republic has a different system of organization of plant protection work. All the scientific and research work in applied entomology is performed almost exclusively by divisions of the six Agricultural Experiment Stations, while the practical measures for controlling the insect pests are carried out by plant protection specialists who are attached to most of the district departments of agriculture. The work of the district specialist is supervised by the Ukrainian Central Plant Protection Station which also is responsible for the statistical survey of injurious insects.

On the staff of the People's Commissariat of Agriculture there are also plant protection specialists whose duties are to plan and to coordinate all measures for the protection of plants in Ukraina.

In Ukraina, there is also another very important organization for the protection of plants which is connected with the "Sakharotrest" (United

Sugar Industries). This organization studies insects injurious to sugar beet and other crops grown in rotation with sugar beet. It consists of seven entomological laboratories connected with the Agricultural and Plant Breeding Stations of the United Sugar Industries.

Practical measures for the protection of sugar beet and other crops used in rotation are conducted by specialists located at the six district offices of the "Sakharotrest".

In the Plant Breeding and Seed Growing Bureau of the "Sakharotrest" there is the Phyto-Entomological Bureau, which handles all matters connected with the control of insects and diseases. This work is coordinated with the work of the People's Commissariat of Agriculture.

3. The small White-Russian Soviet Socialist Republic has only one station for the protection of plants.

4. The Trans-Caucasian Socialist Federated Soviet Republic has the following network of institutions for the protection of plants:

a) Division of Plant Protection at the People's Commissariat of Agriculture in the Republic of Azerbaijan, Georgia and Armenia.
b) Experimental entomological station for the study of insects injurious to cotton in Azerbaijan.
c) Entomological bureau at the Union of Wine Growers ("Concordia") of the Ganjinski District, which conducts scientific and practical work for the protection of vineyards from injurious insects (Elenendorf in Azerbaijan).
d) Division of Entomology at the Sukhum Agricultural Experiment Station.

5. The Middle Asiatic Republics (formerly Turkestan):

a) The Uzbekistan Soviet Socialist Republic has two types of institutions for the protection of plants. One type conducts only practical measures, while the other is occupied exclusively with research work in applied entomology. There is a central administrative office for this work in the People's Commissariat of Agriculture, which organizes and directs the work of plant protection specialists in the ten district agricultural departments. The experimental and research work in applied entomology is concentrated at the Uzbekistan Experiment Station for the Protection of Plants (formerly known as the Turkestan Entomological Station), and also in the Entomological Division of the Shirabudinsky Agricultural Experiment Station (Staraja Buchara).

b) In the Turcomen Soviet Socialist Republic, the central plant protection institution is the Turcomen Plant Protection Station under the People's Commissariat of Agriculture. This station directs and conducts all practical measures for the protection of plants through its staff of specialists located in five district agricultural departments.

Thus, the following groups of institutions in the U. S. S. R. are engaged in applied entomology:

1. Eight divisions and stations under the People's Commissariats of Agriculture of as many Soviet Republics.

2. Five special research institutions covering the territories of their respective republics.
3. Fifty-eight regional, provincial and district stations for the protection of plants.
4. Twelve entomological sections of the Agricultural Experiment Stations.
5. The Phyto-Entomological Bureau and seven Phyto-Entomological laboratories connected with Experiment Stations of "Sakharotrest".
6. Two Entomological Stations in connection with the agricultural colleges.

On the whole about 100 institutions of diverse character and size are working in applied entomology. This does not include specialists for the protection of plants employed in provincial and district agricultural departments.

Comparing these institutions with the pre-war ones, we have now four times as many, and these are more uniformly distributed and serve various portions of the Soviet Union. In the very near future the number of the institutions for the protection of plants will be increased. However, particular attention will be paid to the improvement of equipment such as the erection of insectaries, greenhouses, libraries, museums, etc., as well as to increased appropriations for research work.

II. NUMBER OF SPECIALISTS EMPOLYED IN APPLIED ENTOMOLOGY.

It is natural that the number of people engaged in plant protection work has grown along with the growth in the number of institutions.

In the above mentioned institutions there are employed at present about 600 men, while in the pre-war period there were only about 150 men employed in the various phases of this work. The entomological staff in various institutions varies from five to twelve persons (in the majority of the local institutions the average is from five to six persons).

III. MEASURES FOR CONTROLLING PLANT PESTS.

During the first years of their organization the institutions engaged in plant protection work in the U. S. S. R. were especially devoted to measures for combating locusts and rodents (particularly *Spermophilidae*), but during the last few years considerable attention has been paid to measures for controlling other insects attacking field, vegetable, fruit, and other agricultural crops.

1. Measures for the control of locusts.

The decline of agriculture during the World War, the discontinuance of imports from foreign countries of insecticides and special machines, the difficulties in the early periods of providing these in the U. S. S. R., the departure of many specialists for the war fronts, the drouth of 1921, as well as a series of other causes created very favorable conditions for the unhampered multiplication of numerous plant enemies, particularly locusts.

During the first years following the revolution the locusts caused great damage to agriculture. In 1920 there was a shortage of about 160,000 tons of cereals and 400,000 tons of hay in Siberia due to the ravages of locusts During the same year in the Kirghiz region (now Kazak Republic) locusts

injured 350,000 hectars of cereals, which resulted in a shortage of 100,000 tons of grain. Very serious losses also occurred in Turkestan. In 1921 the number of locusts had increased still further in Siberia, Ural Kirghiz, Volga, Northern Caucasus, Azerbaijan, and Turkestan and had infested over 2,000,000 hectars of land, of which 1,200,000 hectares in crops were completely destroyed.

During the three years from 1919 to 1921 the systematic measures against locusts could only be undertaken on 150,000 hectares. It was not until 1923 that the entomological organizations were strong enough to control the ravages of the insects and check their hitherto continual spread.

In 1922 the measures against locusts were conducted (in round figures) on 400,000 hectares, in 1923 on 1,200,000 hectares, in 1924 on 900,000 hectares and in 1925 on 450,000 hectares. Thereafter, there seems to be a marked diminution of locusts and the measures against them are conducted on an average of about 200,000 to 300,000 hectares annually. The agriculture of the Soviet Union does not at present suffer any appreciable losses from the attacks of locusts.

In connection with the more harmful species of locusts — *Locusta migratoria* L. — we are adopting the new method of destroying the locusts at their source rather than to depend on controlling them in the crop itself. Due to the fact that these permanent breeding places are located in distant and inaccessible spots, this problem was never investigated or studied. In 1925, the first attempt was made to study systematically the habitat of *Locusta migratoria* L., and in 1927 work was organized for their destruction.

The fight against other species of locusts is conducted principally in populated regions, and is of a defensive character.

In order to protect provinces of the U. S. S. R. bordering on foreign countries from the flight of locusts coming from adjoining countries, the Soviet Union during the last five years organized special measures against the locusts in the provinces bordering on Persia and Mongolia. It is also proposed to establish similar measures on the boundaries of Afghanistan and China in agreement and cooperation with the respective governments.

A great deal of attention is being given to the study of locusts and to the methods of controlling them.

The two following methods of control are employed at present.

a) The poison bait method.

This has almost completely superseded the previous method of spraying against non-gregarious locusts and *Dociostaurus maroccanus* Thunb.

b) The airplane method used against *Locusta migratoria* L. at its source.

These habitual breeding places are, usually, overgrown with *Phragmites communis* and are often covered with water, being inaccessible and unsuitable for other methods. At the present time, this method of controlling *Locusta migratoria* L. is receiving full recognition in the U. S. S. R., and with the help of this method, at least 20,000—30,000 hectares are dusted annually.

The experience of the U. S. S. R. in combating locusts by the aid of aviation has interested Turkey, which country invited an entomologist from the U. S. S. R. this year to organize similar work there.

2. Measures used against other insects injurious to cereals.

Among the numerous insects injurious to cereals, bes: 'es locusts, are the following:

a) *Aelia* spp., *Brachycolus noxius* Mordv.;
b) *Tenebrionidae, Elateridae, Chaetocnema* spp., *Phyllotreta vittula* Redt., *Anisoplia* spp.;
c) *Euxoa segetum* Schiff., *Pyrausta nubilalis* Hb.;
d) *Mayetiola destructor* Say, *Osciniosoma frit* L., *Chlorops taeniopus* Meig.;
e) *Cephus pygmaeus* L., *Trachelus tabidus* F.

No practical control method has yet been worked out with regard to the greatest majority of cereal pests, in spite of the fact that some of these pests have been studied over a period of many years. Even where methods of control on a large scale have been satisfactorily worked out they are not entirely applicable, since very little is known as to the causes of outbreaks, and the time of their occurrence cannot be foretold sufficiently in advance to allow for the systematic organization of control work. At any rate, in combating the majority of cereal pests more emphasis is laid upon measures of a purely cultural character, such as crop rotation, time of sowing, fertilization, etc.

3. Measures for combating pests of technical crops.

A. Cotton.

Out of about 60 kinds of cotton pests those of the greatest importance in Central Asia (Turkestan) are: *Tetranychus altheae* Hamm., *Aphis gossypii* Glov., *Caradrina exigua* Hb., *Dociostaurus maroccanus* Thunb. and *Calliptamus italicus* L. In Transcaucasia we have all of the above and also *Chloridea obsoleta* Hb.

Cotton pests in general have not been studied very extensively in the U. S. S. R.

In 1927 about 70,000 hectares of cotton in the Central Asiatic Republics were infested with *Aphis gossypii* Glov. and *Tetranychus altheae* Hamm. During the same year control measures against *Chloridea obsoleta* Hb. in Transcaucasia were undertaken on 100,000 hectares and against *Tetranychus altheae* Hamm. on 25,000 hectares.

The control work against cotton pests is in the hands of the Commissariat of Agriculture, while the funds for this work are assigned to it by the Chief Cotton Committee. Beginning with next year, this committee is planning to organize a series of entomological stations for the purpose of studying cotton pests and applying methods for their control.

Closely allied to the question of combating the existing cotton pests is the problem of quarantining our cotton growing areas against such foreign pests as have not yet invaded the U. S. S. R. The two pests of greatest potential danger to us are *Platyedra gossypiella* and *Earias insulana.* An

interdepartmental committee is now engaged in working out the various quarantine problems. Thus far a method for the regulation of the importation into the U. S. S. R. of cotton from the contiguous oriental countries has been established and a pest survey of the cotton growing areas of Persia has been completed by an entomologist from the U. S. S. R.

B. Flax.

Out of about thirty recorded pests of flax, *Aphtona* spp. and *Phytometra gamma* L. are the most important economically. Early plantings of flax are frequently so badly infested with *Aphtona* that it is necessary to replant them. In case of less severe infestation the crop of fiber and seed is diminished. Due to the lack of a precise method of technique for determining the extent of injury caused by *Aphtona* to flax it is impossible to estimate its economic significance more accurately.

Phytometra gamma L. appears rarely, but during years of mass multiplication it causes great devastations. Thus, in 1922 this insect infested the flax crop of 40 provinces and caused a shortage of about 30%.

Late planting is one of the means for combating *Aphtona,* because the number of insects diminishes as the season progresses and at the same time metereological conditions become more favorable for the growth of flax. *Phytometra gamma* L. is controlled by spraying with arsenical preparations and with solutions of barium chloride.

In the last few years the study of flax enemies has been greatly stimulated on account of the growing economic importance of the crop both in the domestic industries and for the export trade. Measures for the control of flax pests are financed by the United Flax Industries (Lnocenter).

C. Sunflower.

Homoeosoma nebulella Hb. is the most important sunflower insect in the U. S. S. R. In 1914 the Saratov province alone suffered a loss of 75,000 tons of the sunflower crop on account of this insect. In 1923 the same province lost 34% of the seed crop. This pest is of great economic importance also in North Caucasus. The most dependable means of combating this pest is the planting of resistant varieties.

D. Tobacco.

Tobacco culture in the U. S. S. R. suffers mostly from *Gryllotalpa gryllotalpa* L., *Chloridea obsoleta* Hb., *Thrips tabaci* Lind. and *Dasus pusillus* F.

G. gryllotalpa is responsible for a 5—10% loss of the young tobacco seedlings.

Thrips tabaci affects 10—15% of the crop and lowers the quality of the tobacco. There is a total annual loss of from 20 to 30% of the tobacco crop that is directly attributable to the various insects and diseases. These pests are now receiving close consideration in the tobacco growing regions of Northern Caucasus and the Crimea.

4. Methods of combating forage crop pests.

E. Clover.

Clover growing is of great economic importance in the northern and central provinces of the U. S. S. R. On the other hand, it is generally recognized that the success of raising clover for seed and for forage is closely tied up with the science of entomology, since it depends so largely on bumble bees for fertilization and on the successful control of insect pests, chief amongst which are several species of *Apion*. About 5 or 6 Plant Protection Stations are now devoted to the study of clover insects and it is also proposed to establish a special entomological station for the study and control of clover pests. There are a number of publications by Russian entomologists on the subject of clover insects. It has been found that in some clover growing regions mowing will delay the blossoming of clover until conditions are more favorable for its fertilization and less favorable for the infestation by *Apion* spp. Among the less important clover insects are *Eurytoma* spp. and *Tetranychus altheae* Hamm.

F. Alfalfa.

Alfalfa is an important crop in the dry southern districts. Its chief enemies are *Loxostege sticticalis* L., *Otiorrhynchus ligustici* L., *Adelphocoris lineolatus* Goeze. There has been no systematic study of alfalfa pests in the U. S. S. R. and satisfactory control methods are lacking. The work of protecting alfalfa culture from injurious diseases and insect pests cannot, therefore, easily be organized.

5. Methods of combating truck crop pests.

Vegetable culture is widely distributed throughout the U. S. S. R., and in some parts of the country it is the dominant type of farming. The majority of vegetable pests have been studied but little. Some of them, however, are sufficiently well known to permit the undertaking of control measures which are generally simple and inexpensive. Field demonstration work has been carried on during the last 3—4 years for the purpose of stimulating the interest of the population in the subject of pest control.

The following are the most important vegetable pests in the U. S. S. R.: *Brevicoryne brassicae* L., *Aphis gossypii* Glov., *Chaetocnema* spp., *Phyllotreta* spp., *Bothynoderes punctiventris* Germ., *Pieris brassicae* L., *Plutella maculipennis* Curt., *Hylemyia brassicae* Bouché.

Insects attacking melons and cucumbers have been investigated but little, and practically no control work against them is being done at present.

6. Methods of combating orchard pests.

The pests of fruit trees and small berries have been studied quite extensively. Among the most important of these are: 1. *Eriosoma lanigerum* Hausm., *Psylla mali* Forst., *Aspidiotus ostraeiformis* Curtis; 2. *Anthonomus pomorum* L., *Rhynchites pauxillus* Germ., *Rh. bacchus* L.; 3. *Aporia crataegi* L., *Nygmia chrysorrhoea* L., *Lymantria dispar* L., *Malacosoma neustria* L., *Cheimatobia brumata* L., *Cydia pomonella* L., *Yponomeuta malinellus* Zell.; 4. *Nematus ventricosus* L.

Satisfactory methods of control have been developed for many of the fruit insects, although systematic control has only been started during the last few years. For a long time this work was limited to advisory work and propaganda through lectures and bulletins. Then followed the demonstration method. Besides these, in many of the fruit provinces there are being organized measures for more thorough control by establishing centers where equipment can be rented at a reasonable price. The agricultural population has also been supplied with insecticides, the services of special spraying squads, etc., through the various cooperatives.

During the last few years both government and cooperative organizations have extended special credit facilities for the work of pest control, as it was definitely proven that one of the most important causes of loss of production of fruit is due to insect depradations, which annually cause a shortage of about 30%—50% of the fruit crop.

7. Measures for the control of insects attacking vineyards.

The most important insects attacking grapes are:

Phylloxera vastatrix L., *Polyphylla fullo* L., *Otiorrhynchus* spp., *Polychrosis botrana* Schiff., *Theresia ampelophaga* Boyle.

During the last four years special attention has been paid to *Phylloxera.* Plans for the measure of controlling *Phylloxera* and other insects attacking the grapes have been worked out by the Entomological Division of the State Institute of Experimental Agronomy, and have been approved by special conferences and highest governmental organizations.

The survey of vineyards made in 1925—1927 showed wide distribution of *Phylloxera.* The following regions were found free of this insect:

1. Don and Stavropol districts of Northern Caucasus.
2. Dagestan.
3. Astrakhan district.
4. Middle Asiatic Republics.

In 1927 special studies of the biology of *Phylloxera*, the root system of the grape vine and the effect of *Phylloxera* on the same were undertaken in various districts. The effect of *Phylloxera* on hybrids, methods of control by cultivation, disinfection of soil, use of bisulphide of carbon etc., are also being investigated.

Quarantine measures for the purpose of preventing admission of *Phylloxera* into districts which are free from the same will be promulgated during the coming year.

8. Measures for the control of insects attacking stored grain.

The most important pests attacking stored grain are the following:

Calandra granaria L., *Sitotroga cerealis* Schiff., *Ephestia kühniella* and *Acarina* sp.

These insects are undoubtedly of great economic significance, but it si impossible to present their devastations in figures. Besides the lack of methods and technique of estimating the extent of damage, it is very difficult to survey over 25,000,000 individual peasant holdings with the various

types of granaries, various methods and lengths of time of storing grains, etc. The only regions which have had such surveys thus far are Northern Caucasus, Central Chernozem district, and some of the Volga provinces. In these provinces the loss was estimated at about 5%. This survey showed that the insect *Calandra granaria* L. does more injury when grain is moist. When the moisture content increased from 15—16% to 19—20%, the losses of grain from this insect almost doubled.

Injury from Acarina does not often produce loss of weight, but affects the quality of the grain. Flour infested with Acarina has a very disagreeable odor and is also injurious to health.

Besides studying the distribution of insects attacking stored grain practical demonstrations of fumigation with carbon bisulphide and other methods of disinfection have been carried out.

The Soviet government is particularly interested in these measures for the control of insects injurious to stored grain. It is making increased appropriations annually, and is also passing a number of special laws for the control of these insects.

IV. PUBLICATIONS ON APPLIED ENTOMOLOGY.

Most of the entomological organizations in the U. S. S. R. have not yet started publishing their reports regularly.

The following entomological periodicals are appearing at present:

1. Reports of the All Russian Entomological and Phytopathological Congress (Reports of the 2nd, 3rd, 4th and 5th Congresses have been issued).
2. "Protection of Plants from Pests" (Published by the permanent Bureau of the All Russian Entomological and Phytopathological Congresses).
3. "Russian Entomological Review" (Published by the Russian Ento-logical Society).
4. "News of the Moscow Entomological Society."
5. "News of the Division of Applied Entomology of the State Institute of Agronomy" and "Injurious Insects and other Animals in the U. S. S. R." (Also published by the same division.)
6. "Reports of Research Laboratory for Poison Substances" of the People's Commissariat of Agriculture of R. S. F. S. R.
7. "Zachist Roslin" — Published by the People's Commissariat of Agriculture of Ukraine.
8. "News, Reports and Bulletins of the 12 Local Stations for Protection of Plants."

For the last ten years there have also been published a series of monographs, scientific handbooks and textbooks on applied entomology.

Considerable attention is being paid to the publication of popular literature in the languages of various nationalities in the U. S. S. R.

V. TRAINING OF SPECIALISTS IN APPLIED ENTOMOLOGY.

The principal source for recruiting new workers in applied entomology is the special school of zoology and phytopathology in Leningrad. The second place is occupied by universities and colleges of agriculture and forestry.

VI. THE SUPPLY OF INSECTICIDES AND APPARATUS FOR THE CONTROL OF INSECTS.

The question of insecticides and apparatus is of vital importance in the U. S. S. R., inasmuch as the chemical method of control predominates.

In pre-war times and in the first years of the Soviet Government most of the insecticides (and fungicides) and apparatus were imported from foreign countries. During recent years, the demand for imported goods has diminished, as the production of many insecticides (and fungicides) and apparatus has increased.

At the present time we do not need to import formalin, copper and iron sulphates, barium chloride, arsenate of lead, knapsack and hand sprayers and only a few orchard sprayers.

Together with the manufacture of insecticides and fungicides in the U. S. S. R. a thorough research work in the chemical warfare against insects injurious to agriculture is being conducted.

In 1922 the People's Commissariat of Agriculture of the Russian S. F. S. R. established a special Research Laboratory for Poisonous Substances which during its short existence has already conducted extensive studies in the toxicology and other properties of insecticides. It has also developed several new methods of control and organized several collective tests for the study of various questions relating to the chemical control of insects. These tests were conducted in cooperation with local institutions for the protection of plants.

VII. FINANCIAL MEASURES FOR THE PROTECTION OF PLANTS.

Appropriations by the Soviet Government for insect control work are being made more regularly and are increasing annually. In pre-war times the annual appropriations for this work amounted to about $250,000 Since the Soviet Government was inaugudrated, the appropriations have been increasing annually and in 1927—28 they reached a total amount of about $2,500,000 on the government budget alone.

In addition to this amount, the Cotton Committee (mentioned above) expends $500,000 annually, for the control of corton insects. Sacharotrest spent $200,000 on the control of sugar beet insects and during the last few years Lnocenter (organization of flax industries) has appropriated from its funds for the control of flax insects, and the Vegetable Oil Syndicate also appropriated some money for the control of insects attacking oil producing plants. In the future we expect gradually increasing appropriations in the government budget for insect control work.

VIII. SUMMARY.

1. All measures for the protection of plants from insect enemies in the U. S. S. R. are systematically planned, coordinated and controlled by the government.

2. Plant protection stations are being established in those districts which had no entomological service before.

3. The financial aid of the government for insect control is steadily increasing. The fight with the most aggressive insects (locusts, etc.) is made largely at the expense of the government.

The government also pays some of the expenses in connection with the control of minor pests, but its work is primarily directed to the organization of largescale control and to the dissemination of useful pest control information among the tillers of the soil.

4. Practical measures in connection with combating injurious insects as well as all other agricultural measures are carried out with the aid of local agricultural agencies, peasants' committees for self-help, agricultural youths' clubs, cooperative groups, etc.

IX. CONCLUSION.

We fully appreciate that everything done thus far in the field of applied entomology is only a small beginning.

One of our future problems is to strengthen and to further increase the usefulness of all of the above described institutions for the protection of plant life.

Among our other problems are the following:

1. Organization of a permanent plant pest survey.

At the present time this is only organized in the Ukraine, Northern Caucasus, and Siberia. In the next five years this work will be extended to all the regions of the U. S. S. R.

2. Organization of measures for the protection of forests from insect enemies.

Up to the present time measures for forest protection have been undertaken spasmodically and only on a small scale. It is planned to conduct these measures in the future through the existing net of institutions by organizing at these stations special divisions of forest entomology.

3. Organization of measures for the control of insect-parasites of domestic animals.

Insect parasites of animals undoubtedly play a very important economic role in many regions of the U. S. S. R., but as yet they have not been studied sufficiently, and methods for controling them have not been fully worked out. In all probability the study of these insects will be placed in the hands of present entomological institutions.

4. Organizations of measures for the protection of wooden buildings and wood material from insects. Even in the larger cities little attention has been paid to the control of wood boring insects. Undoubtedly measures for the protection of wooden buildings in villages will also be placed in the hands of present entomological institutions.

5. Competitive tests of insect control apparatus to be held in 1931.

The last complete test of apparatus used in insect control was held in 1912. Since then there has been a great assortment of apparatus of various sizes, types and systems in use. The comparative valuation of these will be the problem of the proposed competitive tests in the U. S. S. R in 1931.

We have every reason to believe that the work of insect control in the U. S. S. R., having received unquestionable impetus since the organization of the Soviet government, will proceed still more successfully in the future.

Instrumental Insemination of Queenbees.

Dr. Lloyd R. Watson, Alfred, N. Y.

During the week of the Congress three opportunities were given to witness the instrumental insemination of queenbees. At each of the three sessions the author demonstrated his method with live cultures withdrawn for this purpose from his laboratory, and which he said formed a part of the actual experiments of the current season. Abstract curiosity on the part of those who elected to attend these demonstrations was noticeably lacking, and time consumed in informal questions and discussions after the formal part was over far exceeded the time spent in the formal presentation. The invitation was extended to all to view the technique at close range, and from time to time thru the microscope. A few private repetitions of the demonstration not advertised in the printed program were staged for the benefit of a few scientists who have done or expect to do work of a similar character, and who wished to make a more careful study of certain details of the technique.

Briefly stated the procedure consists in injecting into the oviduct of the virgin queen sperm which has been dissected from the reproductive organs of a selected drone. The operation is by necessity microscopic, and is performed under the lenses of an especially equipped binocular. The tiny drop of sperm is taken up and handled in an all-glass microsyringe which was developed especially for this experiment by the author. A Barber pipette-holder clamped to the microscopic stage holds the microsyringe, and stabilizes its movements in all possible directions. The queenbee is wound down on a tiny operating-table which holds her in a comfortable but perfectly steady position with her dorsal side downward and the genito-anal extremity pointing obliquely upward toward the eye of the operator. Artifical light from a powerful lamp illuminates the critical part of the stage, and a combination of carefully chosen filters screen out such components of the light as might effect the sperms unfavorably. A magnification of 18 diameters is just sufficient to enable the observer to see the swirling motion of the mass of spermatozoids as they pass down the narrow barrel of the syringe and enter the oviduct of the queen.

The wonderful delicacy of the operation was the universal remark of those who were permitted to view it at the closest range, and the perfection of technique employed is illustrated by a single coincidence. As a queenbee was being released from the operating-table after her treatment, she slipped thru the fingers of the operator and soared aloft apparently not debilitated in the slightest by her treatment.

The method of securing the sperm from the drone varied in the different demonstrations. On one occasion the drone was first decapitated.

This caused him to ejaculate completely. The seminal pouch was then drawn out, tapped, and the sperm, losely mixed with mucus, taken directly up into the syringe. On other occasions the seminal vesicles of the male were dissected out, and the sperm was taken directly from them without the ejaculation of the drone. The author informed his hearers that by this latter method he has been able to show conclusively that the pearly white mucus from the accessory mucous glands bears only a practical and not an essential relationship to successful insemination in queenbees. In a casual preliminary announcement he also said that during the present season he had reared workerbees from eggs laid by a virgin queen inseminated with sperm which had been carried for a year within the spermatheca of another queen.

The development of the control of mating in honeybees by this method from crude beginnings to the present stage of its development is fully described and illustrated by its author in a treatise entitled a "Controlled Mating of Queenbees", *American Bee Journal*, 1927.

The Origin of the Hawaiian Odonata Fauna and its Evolution within the Islands.

Professor Clarence Hamilton Kennedy, Ohio State University, Columbus.
(With one diagram.)

The Hawaiian Islands are peaks on a submarine ridge that rises from profound depths. The whole group extends from the South-east to the North-west for about 2000 miles and is divided into the windward group of inhabited islands at the eastern end and the leeward group of atolls and very small islands, thirteen in all, that are uninhabited except for Midway Island which is used as a cable station.

The Hawaiian Islands are tropical and on the north-west slopes where exposed to the moisture laden trade winds are densely wooded. Nearly all contain rough central plateaus ranging from 3,000 to 5,000 feet in elevation, the highest peak in the island of Hawaii attaining an elevation of 13,000 feet with a surrounding area of temperate climate and even snow in winter. The lowlands are entirely tropical, but the higher areas are wet, cool regions in which the Odonate season is restricted to the summer. All mountain ranges with the exception of the rather recently formed peaks in Hawaii show enormous erosion with deeply dissected ranges due to their great age and the very heavy rainfall.

The westernmost island, Kauai, shows the greatest erosion and its age is rated as Eocene or earlier. The next island east of Kauai, the island of Oahu, on which is Honolulu, has re-elevated fossil coral reefs across previously eroded and submerged valleys. These reefs contain fossil shells rated by Bryan as Eocene. The small western part of Maui is very much older than the large eastern part, and he north-western point of the large eastern island of Hawaii is very old, while the great bulk of Hawaii is very recent. All the islands as formed are of volcanic origin, having been built up by repeated eruptions, though Pilsbry, to account for the distribution of land snails, which show no evidence of accidental transport from island to island, hypothecates a Pan-Hawaiian Land Mass antedating the period of volcanic activity and the present chain of islands broken up by partial submergance. The distribution of the flying Odonata needs no hypothetical Pan-Hawaiian Land Mass.

The Odonata fauna consists of about forty forms in thirty distinct species, the other ten being geographical races. Five species are Anisoptera. The remainder are a closely interrelated group of Zygoptera, all belonging to the supergenus *Megalagrion,* named so for the very large size of some of the species. This genus is so closely related to the oriental genus *Pseud-*

agrion that the more generalized species of *Megalagrion* could be placed in *Pseudagrion* without hesitation, if found in the Orient.

This Zypopterous genus of *Megalagrion* is the outstanding feature of the Odonata fauna. Within the islands it has gone through evolution and re-evoultion until now it is split into five or six subgroups, five of which are spread more or less over the whole archipelago. In three of these groups the most generalized species is found in the westernmost island, Kauai, the oldest island, while the stem species of the other two groups are found in Oahu, the next island east of Kauai and also very old. If we check the age evolutionally of the species found on the island of Hawai, the youngest of the chain and at the eastern end of the group, we find its fauna to consist of six widely spread but highly differentiated species and two other highly differentiated species peculiar to that island. Thus the eight species of *Megalagrion* found on the easternmost island, Hawaii, are all tip species in their subgenera. No primitive or stem forms occur there, these being confined to the two western islands Kauai and Oahu. We can interpret this as meaning that *Megalagrion* originated in the two western islands of Kauai and Oahu and developed eastward to the island of Hawaii.

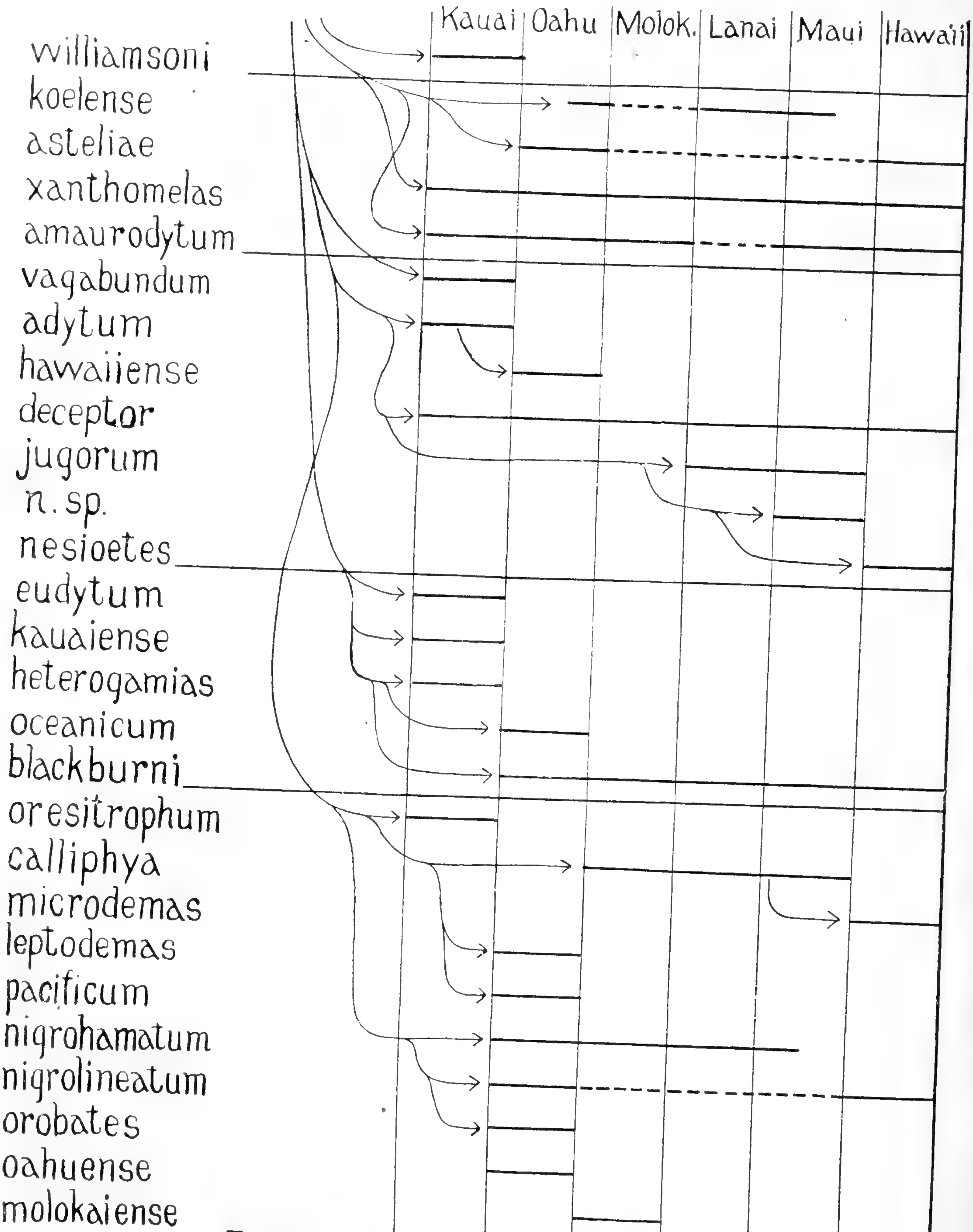
The fact that the primitives are confined to the two westernmost islands and are not found in the middle and easternmost islands would indicate that either there had never been a Pan-Hawaiian Land Mass or that the *Megalagrion* stock entered after the islands had been formed by the submergence of the present channels.

The fact that Kauai has five endemic species that appear to have arisen from one stock would indicate that specialization can occur without the presence of physical barriers.

We conclude that *Megalagrion* was introduced into the islands from Asia in early times, perhaps Eocene,and that at least five stocks evolved within the western islands of Kauai and Oahu from which they evolved gradually eastward, ending in the recently evolved species in the eastern island, Hawaii.

Little is known of the history of this group. The majority as larvae probably live in mountain streams, but one group, that of *M. koelense*, *asteliae* and *amaurodytum*, live in the mud and water collected at the bases of leaves of some of the tropical plants. A few have become pond forms, particulary *M. xanthomelas* of the rice fields, while others are suspected of living in muddy or damp pockets in the higher wet woods.

The Anisoptera represent a different problem. Five distinct stocks of these strong fliers have entered the islands. As to date of entry these fall at once into two groups. Two species, *Nesogonia blackburni* and *Anax strenuus* have been in the islands long enough to have evolved into distinct species endemic to the islands. *Nesogonia* is so close to the holarctic genus *Sympetrum* of fifty or more species that it could be put in that genus with little argument. We do not know *Sympetrum* well enough to say whether *Nesogonia* came from North America or Eurasia. Obviously it has been in the islands long enough to give it a questionable generic distinction. It has developed no distinct subspecies within the islands. *Anax strenuus* is a distinct endemic species in the cosmopolitan genus *Anax*. It is so close



	Kauai	Oahu	Molok.	Lanai	Maui	Hawaii
Endemic	7	6	1		1	2
Spread	3	8	9	9	10	6
Total	10	14	10	9	11	8

Diagram showing the relationships and distribution of twenty-seven forms of *Megalagrion* from West to East in the six large islands of the Hawaiian chain.

to the cosmopolitan species *A. junius*, which is also common in the islands, that it might be a recent offshoot of *junius*. However, the probability is that it has been developed from an earlier entry into the islands. It is recorded mostly from Hawaii, but Dr. Perkins felt certain that it would be found on all the islands because of its very strong flight.

The second group of Anisoptera consists of three species, *Anax junius*, found in all continents except Australia and Europe, *Pantala flavescens*, cosmopolitan in tropical and temperate zones, and *Tramea lacerata* distributed in North and South America. None of these are in any detail distinct from their relatives in other parts of the world and are all obviously very recent introductions. Because of the trade winds from the North-east all three are probably from North America.

Thus Odonata have reached the islands in three periods, the first group, *Megalagrion*, a million or more years back; *Nesogonia* and *Anax strenuus* recently, Pliocene or Pleistocene; and *Anax junius*, *Pantala* and *Tramea* so very recently that they show no change in structure. The first group came from the Orient, the recent group from North America.

In Wegener's book on Floating Continents the suggestion is made that trade wind belts may have changed during the Tertiary, so that in Hawaii in earlier times they blew from the South-east where they now blow from the North-east.

Why the great space of time between the first entry and the last when three stocks entered simultaneously? The only recent great changes in the islands are those due to the entry of the Polynesians about 1000 A. D. Obviously the islands have recently been made more accessible to Odonata. The last three to enter are all pond and rice field species. In correspondence with Dr. E. P. Felt concerning this sudden and very recent influx of Odonata, the latter suggested that, as the islands were formerly largely watered by streams only, pond species had a less chance of survival, while now they find congenial places in the taro patches and rice fields of man.

Field Insects of Russia, with special Reference to Insects introduced into America and their Coefficient of Injury.

D. N. Borodin, New York City.

(With 3 text-figures.)

The practical need of determining losses caused by insect pests is recognized as playing an important part in the work of Economic Entomologists, Agronomists and Statisticians. Those insect pests invisible to a casual observer are probably most important, as they are difficult to detect and therefore to check. In order to determine losses caused to certain plants by a given insect, experiments in artificial infestation with a future comparison of the check plants and infested plants has been recommended by the author in his paper presented at the A. A. A. S. Meeting of 1926, held in Kansas City, Mo. The difference in weight of the yield of normal check plants and infested plants expressed in percentage is called coefficient of injury (C). The coefficient of injury for insect pests attacking certain varieties of crops is quite constant under equal conditions of environment, etc. The coefficient of injury caused by a given insect might be and really should be determined by experiments.

The percentage of infested plants, in a field, is called percentage of infestation (P). Percentage of decrease in yield, or percentage of loss (L), caused by a certain insect pest to a given crop in the field may be determined through a formula. The actual yield (A) per acre of a certain infested field, the possible (theoretical) yield (Y) of grain from the same field when not infested may also be learned from a formula. The actual loss (X) caused by insect pests is the difference between theoretical and actual yields.

The author was fortunate enough to hear Mr. K. M. King's paper on "The Quantitative Methods of Investigation of Field Crop Insects," which deals with insect population in the field.

The Economic Entomologist is obliged at times to forget his biological inclinations and touch upon the question of statistical and practical value of figures of losses. No quantitative sides of insect activities, such as food requirements, density of insect population, their destructive activities, have as yet been studied thoroughly enough.

We are not only in the age of insect domination, but also in the age when figures are of great importance for any future research work and conclusions. To compete with the insect world, we must know the number of cohorts of the enemy's army, its destructiveness and fighting qualities as well as its appetite.

1. *Oscinella frit L.;* Swedish Fly.

The Swedish Fly under Russian conditions is a serious pest for all small grains. Two types of injury prevail: attack on the young plants and attack on ears. The decrease in yield depends on many factors: 1) age of the plant. 2) species and variety of the crop plant, and 3) environmental conditions (weather, etc.).

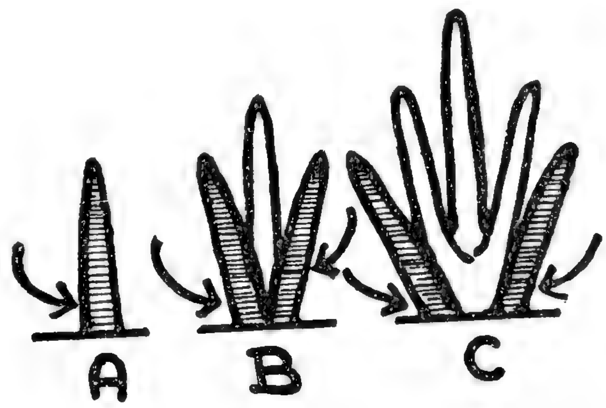


Fig. 1. Scheme of attack by the Swedish Fly on the wheat plant stems in different stages of development. A — attack on main stem; B — attack on secondary stems; C — attack on other stems. (Original).

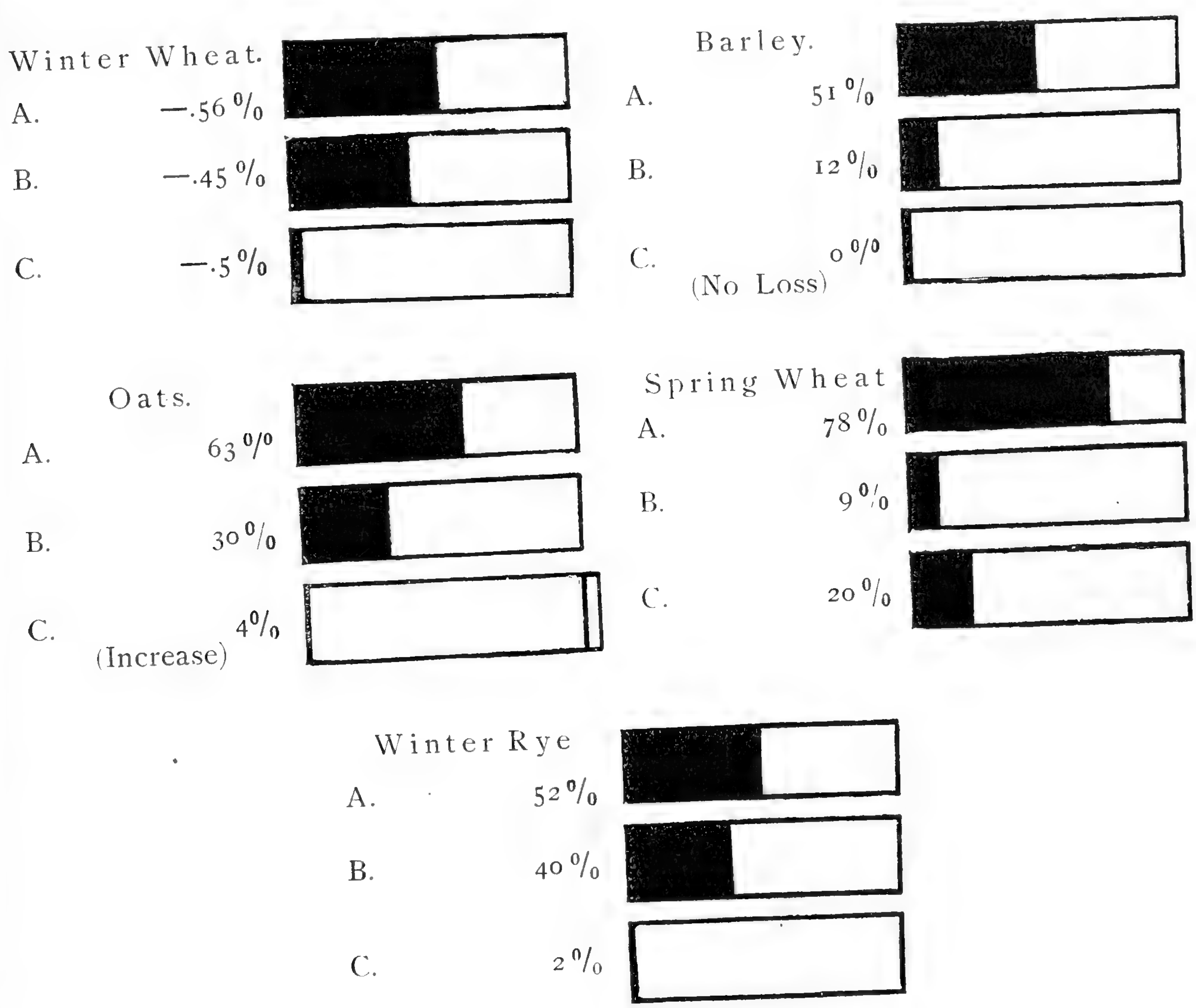


Fig. 2. Coefficient of injury (black) in case of attack by the Swedish Fly on different stems of crop plants. (Original).

Most dangerous is an attack on the main stem, when about 50% of the young plants are destroyed (type A) and the coefficient of injury and percentage of loss are heaviest. Attack on secondary stems (type B) is not nearly as dangerous to the plant, but decreases the yield. When additional stems of a non-yielding capacity are attacked (type C), the coefficient of injury is positive, and a small increase in the yield of about 3 to 5% is evident. This has originally been found out by Mr. N. V. Kurdjumov.

No positive effects on yield due to the presence of four species of parasites, such as: *Trichomalus cristatus* Forst., *Spalangia* sp., *Neochrysochanis immaculatus* Kurd., and *Roptromeris eureva* Htz. (= *wildhalmi* Kurd.) have been estimated so far.

2. *Mayetiola destructor Say;* Hessian Fly.

The character of injury caused by the Hessian Fly is well known, but the extent of injury depends on the age of the attacked plant, on species and varieties of crops and environmental condition during growth.

The percentage of infestation of Spring wheat, according to experiments conducted at Poltava (Russia) indicates that. Durum (a hard Spring wheat) is comparatively resistant and damage caused to it by the Hessian Fly is rather insignificant. The female prefers to lay eggs on soft wheat varieties, as shown in the table.

Table I.

Infestation of Hard and Soft Varieties of Spring wheat by Hessian Fly in the Poltava Province, Russia.

Variety	Poltava % of infest.		Voznesensk % of intest.		Chartoryia % of infest.	
	Bush.	Branch.	Bush.	Branch.	Bush.	Branch.
Hard Wheat:						
Arnautka Kotchina . .	14.47	12.54	0.80	0.77	—	—
Arnautka No. 05 (Ekater. Sta.)	14.90	9.68	1.41	1.38	1.22	0.86
Chernousska (Odess. Sta.)	—	—	0.96	0.91	—	—
Aver. for Hard	14.86	11.11	1.58	1.53	1.22	0.86
Soft Wheat:						
Belokolosska "Poltavka"	76.55	44.24	8.23	7.03	4.76	3.82
Belokolosska "Karlovskaya".	79.39	59.39	9.65	8.50	1.49	1.07
Albidum No. 604 (Saratov Sta.)	72.34	67.19	8.42	6.73	1.49	1.25
Albidum No. 721 (Saratov Sta.)	72.64	65.39	10.38	9 10	0.76	0.58
Lutescens No. 62 (Saratov Sta.) . , . . .	72.25	57.65	10.81	9.11	0.88	0.67
Girka No. 274 (Odess. Sta.)	79.67	66.34	4.11	3.69	2.94	2.07
Aver. for Soft	75.47	60.30	8.60	7.36	2.05	1.57

Experiments in 1925 by A. Znamensky show this difference in proportion = 679 eggs for Durum and 1,720 for soft wheat.

Table II.

Number of Eggs laid by the Hessian Fly in Hard and Spring Wheats according to Experiments at the Poltava Experiment Station.

Variety	Number of plants	Eggs deposited	Average for one plant
Triticum durum hordeifrons	20	679	33.8
Triticum vulgare lutesens	20	1720	86.0

The coefficient of injury (in case the number of puparia on stems varies) estimated in Poltava in 1925 is shown below.

Table III.

	1 larva	2 larva	3 larva	4 larva
Spring Wheat .	59.4	70 9	68.4	89.9
Winter Wheat .	30.0	53.4	56.7	71.7
Winter Rye . .	27.4	32.3	47.3	68.9

The average coefficient of injury in the same localities during different years varies to a certain degree, as below.

Table IV.

	1896	1923	1924	1925
Spring Wheat .	70.8 %	32.5 %	—	73.5 %
Winter Wheat .	—	33.4	41.1	52.4
Winter Wheat .	—	—	—	44.0

It is interesting to compare these figures for Winter wheat with those given for the State of Pennsylvania in 1918—1924. Table I shows that the coefficient of injury has its variations in the same locality during different years. In Pennsylvania the coefficient of injury is about twice lower than in Poltava. On the table below figures of variation of the coefficient of injury in the State of Pennsylvania are shown in connection with the different larval population on the plant (from 1 to 4 larva).

Table V.

Years	1 larva	2 larva	3 larva	4 larva
1918	11.7	11.2.	12.3	25.6
1919	28.5	33.4	32.4	49.3
1923	14.2	15.4	11.9	26.7
1924	12.7	10.6	11.7	20.5
1924	13.4	21.4	25.5	39.4
1924	21.5	25.6	30.9	38.3
Average	15.9	18.9	19.6	31.8

The presence of parasites in Russia, such as *Platygaster minutus* Lind., is estimated as a considerable factor in the natural control of the Hessian Fly, often destroying 100% of larvae. *Merisus intermedius* Lind. (*destructor* Say?) destroys 70% of puparia. *Eupteromalus arvensis* Kurd.,

Meroporus crassicornis Kurd. and *Entedon epigonus* Walk. are less effective.

3. *Contarinia tritici Kirby;* Wheat Midget.

The Wheat Midget as a wheat pest was discovered by Kirby in Suffolk, England, as far back as 1785. Several outbreaks of this pest have damaged wheat crops in Russia and in England. In 1914 the author had an opportunity to study the wheat midget's mass appearance*) in the Poltava Province (South Russia, now Ukrainia). An outbreak of this pest started in 1912 and continued till about 1918.

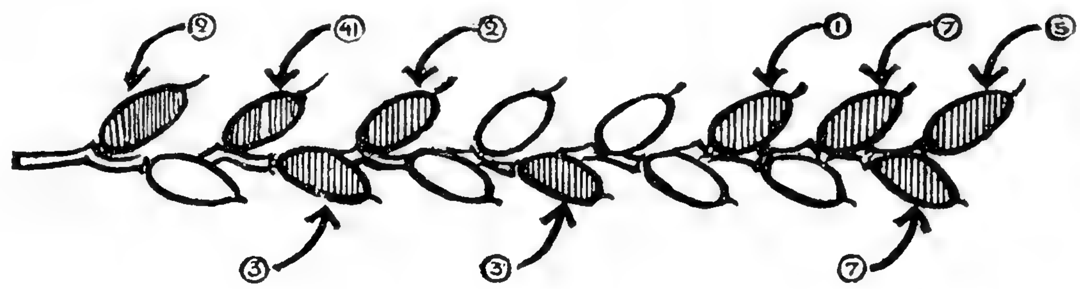


Fig. 3. — Scheme of infestation by "Wheat Midget" of ear of Winter wheat. Figures show the number of larvae or puparia (5) in separate spikelets of the ear. (Original).

The larva attacks single grains in the spikelet of ears during a very early stage of growth and destroys it. Usually more than one larva attacks a single grain, but destruction at times is not accomplished by only one larva. During the threshing period and future processes the damaged grains disappear, practically destroyed by the insect.

Table VI.

Showing analyses of ears of Winter Wheat infested with Wheat Midget. Upper horizontal line, 23 spikelets from the base of the ear. First vertical line, the number of ears. The figures represent the number of larvae in the spikelets. (Original).

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	—	—	—	1	26	—	—	1	—	—	1	—	4	—	—	39	6	—	28	9			
2	2	—	41	3	2	—	—	3	—	—	1	—	7	7	(5)†	—	—	—	—				
3	—	—	—	—	—	—	4	—	—		—	—	—	—	—	—	—	(1)†	—	—	—	—	—
4	—	—	—	—	—	—	—	—	—	—	—	—											
5	—	—	—	—	—	—	—	—	—	—	—	—	—	—									
6	—	—	—	11	—	2	—	19	—	3	—	—	2	—	28	7	9	—	—				
7	—	—	—	—	—	—	—	—	—	—	—	—	—										
8	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	(1)†	—	—
9	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—			
10	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—		
11	—	—	—	—	13	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
12	—	—	—	—	1	—	—	—	1	3	—	3	5	—	—	—	—	—					
13	(1)†	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—							
14	—	9	—	—	—	—	6	—	—	—	19	—	—	—	31	—	—	—		—	—	—	—
15	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—		—	—	—	—
16	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	—	—	—		—	—	1	12
17	2		8	—	—	—	—	—	—	—	—	—	18	1	—	—	—	—					
18	—		—	—	—	—	—	—	—	—	—	—	—										
19	—		1	—	—	—	—	—	—	—	2	—	—	—		—							
20	—		—	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—		—			

*) D. N. Borodin: "Mass appearance of wheat midget in 1914"; in *Khoziaistvo*, No. 43—44, 1915, Kieff.

†) In parenthesis = puparia.

Percentage of infestation was estimated for 100 single ears containing 2196 single grains. It has been found that 212 of these grains (or 10.06%) had been destroyed. This gives an absolute figure of the percentage of actual loss, or L, in the yield of wheat.

Table VII.

Crop	Place	Sowing date	Time of analysis	Number of ears analysed	Number of grains	Number of grains destroyed	%
1. Winter Wheat	Poltava Exper. Station	—	June 11—13	100	2106	212	10.01
2. Winter Wheat		Aug. 5	June 27	100	2736	267	9.75
3. Winter Wheat		Aug. 13	June 27	100	2298	144	6.26
1. Winter Wheat		Aug. 28	June 28	100	2354	26	2.09
5. Winter Wheat		Sept. 5	June 30	100	2624	19	0.72
6. Winter Rye	Tzarichanka	—	June 16	100	3896	175	4.49
7. Winter Wheat	Karlovka	—	June 20	93	1386	212	15.2

The sowing date has some influence on the percentage of infestation, and analyses 2, 3, 4 and 5 show that clearly. Winter Rye has not been infested so serverely, but single grains in spikelets at the base of the plants have been infested very badly. A maximum of larval population has been located near the base of the ear and about thirteen of the uppers following.

When the grain itself is destroyed by insect pests we have no necessity of estimating the coefficient of injury, but we have figures of actual loss in yield, or "L." When Winter Wheat and Winter Rye ears have been infested about 80—90%, the larval population may be estimated as shown above; each group of larvae proved injurious only to one single grain. Injury caused to plants by the Swedish Fly, Hessian Fly, European Wheat Sawfly, etc., depresses the normal feeding of plants, thereby decreasing the yield of grains, but not destroying them altogether, whereas the Wheat Midget, on the contrary, attacks the grain directly, destroying it entirely.

4. *Cephus pygmaeus L.;* European Wheat-Stem Sawfly.

The European Wheat Sawfly is an object of very intense study to determine the coefficient of injury, owing to the simplicity of the cause of injury, i. e. attack on the stem.

The geographical distribution of this Sawfly is wider than indicated on some maps published recently and covers all European Russia, except the Northern region, all Ukrainia, Crimea and entire Caucasus, as well as Asia Minor.

Before the author started his investigation in Stavropol (in Caucasus) in 1913 *), at least two other Entomologists carried on the same work at various times and localities. A Russian Entomologist, Mr. V. N. Schegolev, now continues the author's work commenced previously at Stavropol in Caucasus. V. N. Schegolev analysed the stubble of different crops in Northern Caucasus (in the year 1925—1926), which were infested

*) See D. Borodin, Cephus pygmaeus on the Western Exper. Field of the Stavropol Agric. Exper. Station; in *Khoziaistvo*, No. 33—36, 1915.

by *C. pygmaeus* and *Trachelus tabidus* *). Most of the stubble samples were taken in Stavropol, Eissk and Essentuky.

Analyses have been made of about 497,622 separate plants of Winter Wheat, Spring Wheat, Spring Barley, Winter Barley, Oats, and Winter Rye. Results of these analyses were given in various tables, showing the following maximum percentage of infestation: for Winter Wheat 51.36%; Spring Wheat 35.33%; Winter Rye 13.49%; Spring Barley 15.88%; Winter Barley 2.15%; Oats 6.75% and "Surja" (or a mixture of Winter Rye and Wheat) 13.82%.

A high percentage of infestation presents excellent possibilities for studying the coefficient of injury. Mr. Schegolev's conclusion is that the coefficient of injury varies to some extent and depends on metereological conditions, time of infestation and locality. Not all data are available as yet, but some are presented already, as shown in the table below:

Table VIII.
Coefficient of Injury Variations; *Cephus pygmaeus* L.

Variety	Rostov on Don 1925	Rostov on Don 1926	Eissk 1926	Stavropol 1926
Winter Wheat	—	16.33	22.75	10.07
Spring Wheat	4.70	16.59	4.28	12.14
Spring Barley	—	10.98	—	—

Mr. Schegolev found that during a dry year, as happened in 1926, the coefficient of injury had increased. Other data show that several different varieties of crops reacted on the injury in a different manner, owing to a fluctuation in regime requirements, smaller cells in tissues of plants, etc. etc. A comparison of the coefficient of injury, therefore, should be made in the future not only within the species, but also within the variety (or race) of the crop, and figures resulting therefrom must serve for further comparisons. Numerous analyses of stubble of different crop varieties gave a variation in the coefficient of injury during certain years. As the female always chooses the best stems of Wheat for oviposition, it is necessary (in order to compare the effect of the injury) to use stems of the same size, thereby assuring correct figures **).

Collyria calcitrator Grav. in Russia kills about 95% of the larvae; *Picrocytus scabriculus* Nees also appears in small quantities; the first species is quite an important factor.

The author has been unable to make a complete comparison of results of the coefficient of injury investigations which have been conducted in the United States. A recent publication by Mr. D. Ries, 1926, gives an idea of infestation of fields by the sawfly. However, the presence in the same field of the Hessian Fly injury found on the same stems makes a correct comparison difficult.

*) Schegolev, V. N., European sawfly (Cephus pygmaeus L.) and Black sawfly (Trachelus tabidus F.) in Stavropol, in 1925; in *News of Stavropol Station for Plant Protection*, 1926.

Id., European sawfly. Ecology and Experiment on Control; in Rostov-on-Don Agric. Exper. Station, Bull. 228; Pub. in *Sevkavkraizu*, 1927. pp. 1—71.

**) Kurdjumov and Znamensky.

5. *Pyrausta nubilalis Hübn.;* European Corn Borer.

The European corn borer is a native insect of European and Asiatic Russia. It is common in many localities of Siberia, Turkestan, Amur Region and European Russia. It also appears in Ukrainia, Crimea, Caucasus, South-eastern and Middle Russia, and as far North as the provinces of Tula, Kaluga, Riazan, Tambov and Simbirsk*).

Corn is a comparatively new crop in Russia and the corn belt covers a rather small area, but is well established in Ukrainia and Caucasus. In Russian conditions, the European corn borer as a pest is not considered very destructive, and Russian Entomologists pay very little attention to it. It is important to notice, however, that the European corn borer is beginning to be considered as a pest, being previously only known as a pest of Russian broom corn millet (or Proso-Millet), *Panicum milleaceum*, hemp and hops; even the Russian name of the pest translated into English means "millet moth".

Millet, when early grown, may be damaged very severely by the corn borer, as the stems are cut, strewing the field with their dried parts and bore-dust.

Most of the Russian authors indicate that the above mentioned three crops always are and have been more severely infested by the corn borer than corn. This statement is of considerable importance and is of practical value, if absolutely correct.

Corn fields heavily infested by the corn borer are described by Russian Entomologists as producing an effect of a cattle herd having passed through it, as most of the stems are broken and bent in various directions, with bore-dust covering the stems. The ears, however, have a normal appearance, but they ripen earlier and the grains are not well tightened to the cob.

In case of injury to the ear proper and to grains the quality of yield decreases, due to decay and direct destruction of grains, etc., often being found covered by mold. The most fatal case of injury is the attack of larva at the base of ears. In Russian conditions injury caused by the corn borer is not considered from the point of view of a decrease in yield, but decrease in the quality of corn and to a great extent its food and market values. The coefficient of injury in this case has not been estimated exactly till the present time.

The character of the injury caused by the European corn borer may be divided into the three following types: attack on stem, attack on ear or cob, and attack on grain directly. The results of such injuries are accordingly different. In the first case the yield decreases and the coefficient of injury may be estimated, but with special reservations owing to the fact that infestation by one or two larvae does not produce a great enough effect to be taken into serious consideration. However, five larvae in the stalk have a decidedly destructive result on the yield. The larval population in corn plants in Russian conditions (in Poltava) is 18—20 larva to one stem (Znamensky, 1926), and 50—60 in Don Province (Dobrodiev, 1920). Flint varieties of corn of Bessarabian origin, such as Chinquantino,

*) That the European corn borer is present in India, Asia Minor, Japan, Egypt and Southern Europe is well known.

etc., with a few local dent varieties are prevailing corn varieties grown in Russia.

Where the European corn borer is concerned, the question of the exact coefficient of injury remains unsolved. Proper figures are still unavailable and a thorough study is most necessary in future.

What is the actual effect of the larval attack on stems of the corn plant and what larval population causes a decrease in yield or quantity of protein, oil and carbonhydrates in the cob? We are aware that five larvae are already very injurious by destroying the grain. We also know that a direct attack on the ears decreases the yield. This case is quite similar to that of injury caused by the Wheat Midget.

We do not know why the corn borer is so destructive in the United States and Canada, and is still considered a secondary pest in Russia.

A comparison of figures must be made of the percentage of infestation, larval population, coefficient of injury when the stem is attacked, and percentage of actual loss in case of ear injury. Also, a comparison of such figures with those arrived at for different crops in various countries may solve many questions of great importance. The value of parallel comparative studies of insect pests in different countries should be highly recommended. It would be very important to have comparative data of a decrease in yield of infested corn (as well as other plants) in order to find the resistance or special susceptibility of some varieties. There are some indications that not all varieties of crops, plants and food plants are equally susceptible to the European corn borer, as some have been badly infested, but were comparatively quite resistant.

We have also to deal with the instinct of the female European corn borer, which deposits its 350 eggs in groups of 15 to 50*) on the leaves of food plants. We must learn more of this instinct. A possibility of finding a "trap-crop" is not excluded, considering that only few original food plants are present in the New World.

It seems to us that nature controls the European corn borer in Russian corn fields better than in the United States, and that the role of parasites in this instance is not of principal importance. Parasites have been found in but comparatively small quantities.**)

We have at present only sparse data dealing with Russian broom corn millet infestation by the corn borer. At the Voronej Agricultural Experiment Station there have been planted 20 different varieties of millet. It has been found by Dobrodiev (1920) that the variety Dacicum 244 gave a percentage of infestation as high as 39—64%. At the same time, Sanguineum 25 and Flavum (?) 155 had an infestation of only 14—36%. The first variety (Dacicum) belongs to the closely grown type, the second to the branchy type.

We must not forget that many native and cultivated plants have been in existence long before corn appeared in Southern Russia as a crop. Could the presence of a wild form of hemp *(Cannabis sativa)*, wild *Humulus*, *Panicum crus-galli*, *Sonchus arvensis*, *Chenopodium*, *Xanthium strumarium*,

*) Or 15—20, Dobrodiev, 1921.

**) There have been found the Tachinids *Ceromasia senalis* Mg. and *Eulimneria rufifemur* Thoms. (with a super-parasite *Dibrachis bousheanus* Rtz.)

Lamium album, Setaria viridis, Arundo donax, Artemisia, Conyza squarrosa and others attract the attention of the female corn borer moth?

Conclusion.

Two paradoxes: first, late infestation by the Swedish Fly causes a slight increase in yield in the infested plant, and, second, the tremendous loss caused by the Wheat Midget, regarded as an unimportant pest, shows how little is known as yet about the exact amount of injuries caused by insect pests.

The coefficent of injury varies to a certain degree in case of an attack by the same insect on the same crop plant. This variability depends on many factors. The larval population of the attacked plant is one of the factors of this variation. Different varieties of crop react on the attack by insect pests in quite a different manner. To determine the coefficient of injury the same varieties of plants should be used.

The coefficient of injury varies to some extent during different years, depending on weather conditions and other factors as yet unknown.

Figures of the coefficient of injury determined in different localities vary considerably; this local variation should be investigated more thoroughly, in particular exactly the same varieties of plants should be studied in the various localities.

A comparative study of the coefficient of injury in different crop varieties, as well as a comparative study of the percentage of infestation is strongly recommended.

The Relation of Windfalls to Bark-beetle Epidemics.

J. M. Miller, Entomologist, U. S. Bureau of Entomology, Forest Insect Laboratory, Stanford University, California.

(With 2 diagrams.)

INTRODUCTION.

Because many species of tree-killing bark-beetles attack and develop their broods in recently felled trees, it is readily assumed that certain types of forest debris become a potential threat to standing timber by serving as a breeding ground for swarms of bark beetles. Conditions such as those found in the slash left from large logging operations and in trees thrown down by violent windstorms furnish certain bark-beetles with a favorable medium in which to multiply. When the supply of down material is exhausted, we may expect these insects to attack standing living trees in the vicinity in such numbers that a sharp increase in timber losses will follow. The evidence furnished by bark-beetle epidemics that develop in and around cutting operations and windfalls afford the only tangible test of this theory.

Windfalls more favorable to bark-beetles than slash from logging and other operations.

So far as the results of observations are available, it is becoming apparent that the type of slash has much to do with the success with which bark-beetles increase and subsequently develop serious attacks in standing timber. In the slash from logging and right-of-way operations in western Yellowpine stands it has been found that only rarely do bark-beetles increase to a point where they seriously menace the surrounding forest areas.*) On the other hand, the recent study of two windfalls in this same type of forest indicates that the loss of a considerable quantity of standing timber has resulted from bark-beetle epidemics that had their origin in wind-thrown trees.

Slash is the term generally used to define the tops, limbs, cull logs, etc., left in the woods after the trees have been cut and the merchantable logs removed. The moisture supply for the inner bark is immediately cut off at the time of felling, and when the limbs have been lopped, evaporation of moisture in the log through the foliage stops. Abnormal moisture conditions are promptly set up within the cambium area in which bark-beetles feed, so these insects must contend with either a rapid drying-

*) Relation of Insects to Slash Disposal: Dept. Cir. 411, U. S. Dept. of Agr.

out as in the limbs that are cut off, or a temporary excess of moisture in the inner bark of the logs depending on the nature of the slash, site, and weather conditions. Although bark-beetles may enter the logs in slash material, conditions rapidly become unfavorable for brood development, and a high mortality often occurs during the period of larval feeding. Studies by both Patterson*) and Person**) have shown that the mortality in slash is frequently so high that the number of new beetles emerging from a log is less than the number of their parents that attacked it. Where this occurs, slash from an entomological standpoint becomes a benefit to the surrounding forest, as its net effect is to reduce the bark-beetle population in the area.

In windfalls, however, no such immediate disturbance of the tree's normal functions occurs. The majority of the trees are merely pushed over, leaving part of the root system still in the ground. Moisture conditions in the inner bark are therefore nearly like those of the living tree for a much longer period than in logs, where the tree is cut off at the base. The roots are still able to supply moisture to the foliage which, in turn, can continue the process of respiration. The outstanding effects upon the tree are the loss of approximately half or more of its root system and a very radical disturbance of the exposures of the foliage to light. Under these conditions a wind-thrown tree may continue to live in its prostrate condition for several seasons, but its capacity to grow and to resist bark-beetle attacks becomes greatly lessened. Its condition is comparable to that of a tree weakened both by drought and by partial defoliation, conditions very favorable for the attack of bark-beetles and the successful development of their broods.

Entomological Aspects vary according to type of Windfall.

Windfall conditions vary greatly in the quantity of material that may be blown down during the course of a season within a given area. A few trees go down every season, not altogether as a result of unusual storms, but through failure of the root support and through weakening of the trunk by fire scars, decay, and boring insects. This minimum type of damage, which seldom attracts notice in the heavier stands, differs in its entomological aspects from situations where from 20 to 50 per cent of the stand may be blown down in masses on the more exposed sites. It has been found that in areas where scattered windfalls occur, little change attributable to this source follows in the bark-beetle infestation in standing timber; whereas around the mass type of windfalls bark-beetle epidemics of a virulent character may develop.

Two localities where heavy windfall damage occurred in western Yellow pine and Jeffrey pine have been studied in their entomological aspects, and give a fair index of what is to be expected in the types represented. These are discussed in the following pages.

---

*) Patterson, J. E., The Relation of Highway Slash to Infestations by the Western Pine Beetle: U. S. Dept Agr. Tech. Bul. 3.

**) Person, H. L., Chilkoot Road Slash Study; Ms. Rept.

THE UPPER LAKE WINDFALL, CALIFORNIA NATIONAL FOREST, 1921.

Conditions within the Area.

A storm that occurred in January 1921 caused an estimated loss of 25,000,000 board feet of timber on an area of about 20,000 acres in the California National Forest. The wind, coming from the North-east, blew down trees in masses, in some places more than 50 per cent of the stand being blown down on the most exposed slopes. The volume of the more important species blown down was estimated as follows:

	Board feet
Yellow pine	15,000,000
Douglas fir	8,000,000
Sugar pine	2,000,000

Within this region the following are the important tree-killing beetles of these hosts:

Yellow Pine.

Western pine beetle *(Dendroctonus brevicomis* Lec.), Engraver beetle *(Ips confusus* (Lec.)), *Ips oregoni* (Eich).

Sugar Pine.

Ips oregoni (Eich.).

Mountain pine beetle *(Dendroctonus monticolae* Hopk.), Engraver beetle *(Ips confusus* (Lec.)).

Douglas Fir.

Douglas fir beetle *(Dendroctonus pseudotsugae* Hopk.), Flat-headed borer *(Melanophila drummondi* Kirby), Fir engravers *(Pseudohylesinus nebulosus* Lec.), *Scolytus subscaber* (Lec.).

Preceding the windstorm, the main losses due to insects in this region were caused by the western pine beetle in Yellow pine and the mountain pine beetle in Sugar pine. For a long period this infestation had remained in an endemic condition, an average of not over 25 trees being killed annually per timbered section. Very little insect loss had been found in living Douglas fir in this area. The two species listed above, together with a number of secondary engraver beetles and borers, were common in recently felled logs.

Developments following the Windfall.

With the sudden creation of this great volume of down logs it was obviously impossible for this limited bark-beetle infestation to furnish attacking insects for all the favorable host material in the spring of 1921. It was necessary first that the beetles increase their numbers. This increase developed rapidly during the first season after the windfall, but it occurred almost entirely in the down logs. The degree of infestation in the standing trees that were killed did not increase materially over that of the two seasons preceding. In the spring of 1922 there was no indication from the number of standing infested trees that a potential bark-beetle outbreak existed in the region of the windfalls.

Suddenly, during June and July of 1922, the western pine beetle began to attack standing trees in unprecedented numbers. Trees were killed in groups of from 50 to 100, whereas in previous seasons such killings

occurred only in single trees or in groups rarely exceeding four or five. The mountain pine beetle increased in a similar manner in sugar pine, but no groups of more than 20 infested trees were noted, owing to the small numbers of these trees in the stand. The infestation resulting from the attack of this summer generation of beetles suddenly increased the losses from 25 to more than 200 trees per timbered section.

In the fall of 1922 the attacks of the generation of beetles that was to hibernate showed a very pronounced falling-off in numbers. The large grouping of the attacks disappeared, and the additional loss dropped to less than 30 trees per timbered section. In 1923 the seasonal loss declined to a point even lower than that for 1921, the year preceding the windfall. The progress of this outbreak in combined Yellow pine and Sugar pine losses, based on a complete survey of a check area of 786 acres, is shown in the following table:

Year	Number of standing trees killed	Board foot loss
1921	28	60,190
1922	228	403,810
1923	13	23,990
1924	25	12,970

Estimates of both windfall and insect losses for the windfall area and the surrounding territory, approximating 72,000 acres, are shown in fig. 1, p. 996.

Distribution and Character of the Insect outbreak in Standing Trees.

This particular outbreak of 1922 localized mainly in the region of the windfall. No epidemic of similar intensity occurred elsewhere in the Yellow pine belt of northern California, which supports the assumption that the sudden outbreak in 1922 in and around the windfall areas was due to beetles coming out of the down logs. Although the heaviest killings were found close to the largest bodies of wind-thrown trees, groups of beetle-killed trees were found at points from 6 to 8 miles distant from any mass of windfalls. Apparently this was the result of a flight of part of the beetles emerging from the down logs.

The striking absence of any noticeable killing of Douglas fir was one of the outstanding features of this epidemic. This tree suffers very little from bark-beetle in the Pacific Coast region, and neither before nor after the windfall did any serious loss develop. Apparently the infestation in this host was of such a secondary character that it could not gain momentum in the standing timber after the down logs became unsuitable for brood development.

Another feature was the absence of engraver beetle outbreaks in Yellow or Sugar pine. The species of *Ips* are common in down logs and at times, as during drought periods, cause small local outbreaks in living trees on the poorer sites. In this case, although engraver beetles were noted in some of the down logs, they did not appear as a factor in the subsequent killing of standing timber.

Probable Cause of the Epidemic and of its Decline. In October, 1924, Mr. H. L. Person, of the Bureau of Entomology, and Supervisor Coffman, of the California National Forest, carried out a brief survey to determine the final developments connected with this outbreak. One object of this study, which supplemented previous surveys in 1922 and 1923, was to obtain enough data to determine the source of the beetles causing the 1922 outbreak and the reason for the remarkable decline in their numbers that occurred in the fall of that year. Strip surveys were run through parts of the windfall area, and logs were examined to determine the emergence per square foot in this class of material; in addition, standing beetle-killed trees were selected and samples of bark taken to determine the ratio of attacking beetles to the emerging progeny.

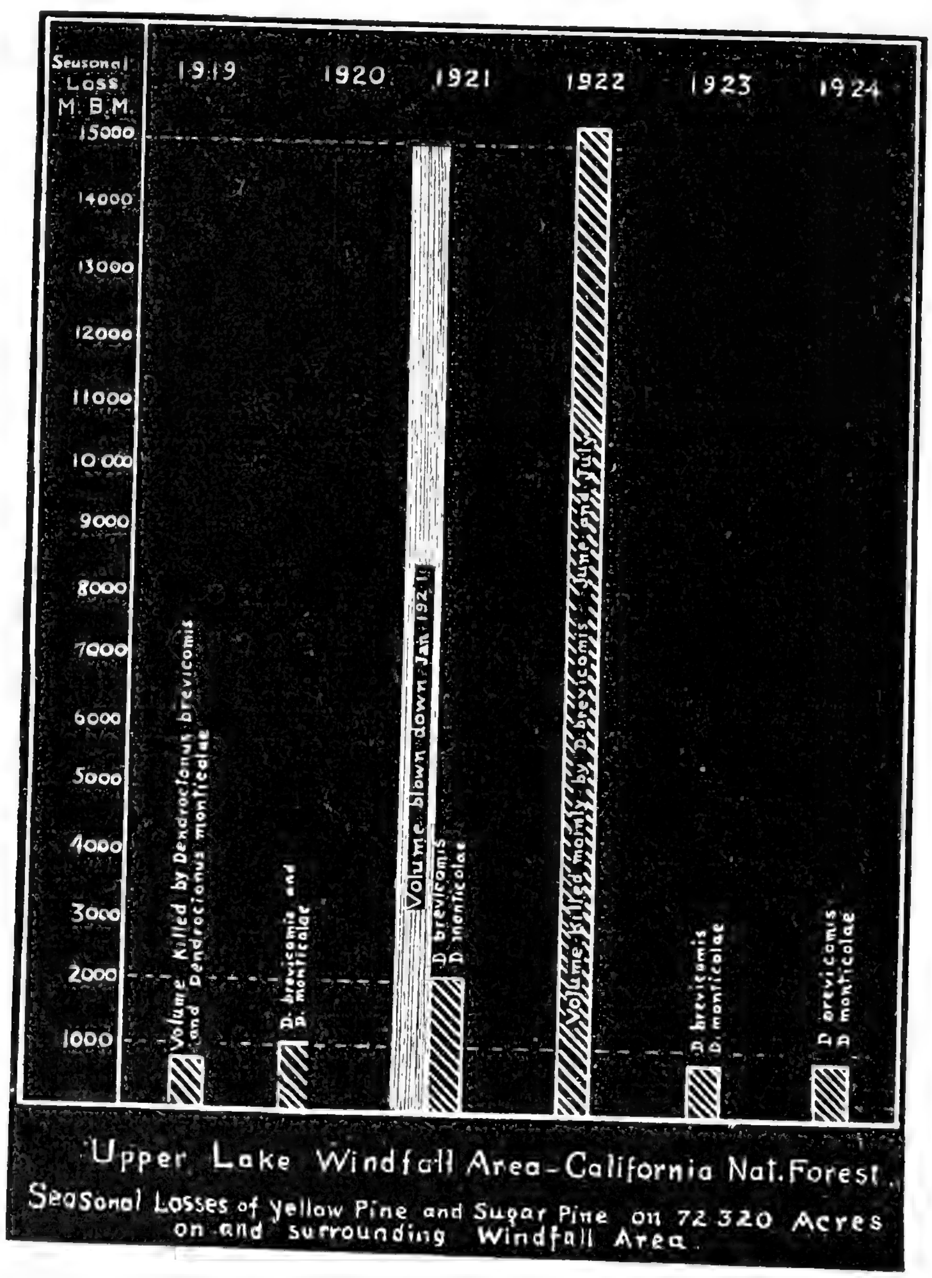


Fig. 1.

Owing to the limited time available, and to the fact that after two years much of the bark material had deteriorated to a point where accurate counts were impracticable, it was not possible to carry this line of analysis far enough to obtain conclusive evidence. The results obtained, however, indicated that a high percentage of the pine windfalls were only lightly attacked by beetles, and that in this material the average emergence per square foot was much lighter than in standing beetle-

killed trees. Although the beetles that left the windfalls must have been the largest contributing source of supply for the attacks that occured during the summer of 1922, estimates, based on the averages obtained, indicated that not enough beetles had developed in the windfalls to account in full for the number of attacks in standing trees in the summer of 1922. This would indicate that some attraction in the vicinity of the windfalls may have lured these insects from outside areas to augment the sudden killing of standing trees during the summer of 1922, for it was adequately established that only a small percentage of the beetles making the 1922 attacks could have come from standing infested trees on or near the area involved in the epidemic.

The cause of the sudden decline of the epidemic was also found to be complicated, but at least one obvious factor dominated all others: the overcrowding of the parent beetles which attacked and killed the large groups of trees during the summer of 1922. This is brought out by a comparison of the number of beetles of the 1921, 1922, and 1923 generations that attacked with their subsequent progeny emerging from the trees. The figures are given in the following table.

Season	Number of beetles per square foot of bark surface	
	Attacking	Emerging
1921	27	80
1922	41.2	48.5
1923	29.2	86.5

This indicates an overconcentration of beetles of the 1922 generation on the trees attacked. The killing of large groups of trees during that season was apparently the result of the building up of the bark-beetle population within a small area. The attacks within the bark were so numerous that there was not enough food to supply all the developing broods; as a result the emergence was only half the normal for the preceding and subsequent seasons. The work of parasites and predators was also considered, but only to a small extent can they account for this diminution of progeny in the broods.

THE INYO-MONO WINDFALL of 1923.

Conditions within the Area.

A storm that occurred in February 1923 caused the loss of a volume of timber estimated at 12,500,000 board feet on an area of 32,000 acres east and north of Mammoth, Calif. This windfall differed greatly as to conditions of type and site from the one just described. About half the loss occurred on a few small local areas, totaling 2,640 acres. From 20 to 50% of the stand was blown down where the heaviest losses occurred, but this condition merged into areas where the windfall loss was less than 2% of the merchantable standing timber.

The principal host tree involved was Jeffrey pine. White fir and Lodgepole pine composed so small a proportion of the stand as to be negligible from an entomological standpoint. The important bark-beetle enemies of Jeffrey pine in this area are *Dendroctonus jeffreyi* Hopk. and *Ips oregoni* Eich. The former attacks primarily the mature trees,

and for several seasons preceding the windfall had been in an endemic status, the average annual loss being 20 trees or less per section. The latter appears occasionally in sporadic local outbreaks, developing mainly in tops and young trees.

Developments following the Windfall.

Bark-beetles, mainly *Ips oregoni*, began to attack the down material in 1923, but only a small percentage of the logs became infested during the course of the season. This attack, with successful development of the broods, continued during the season of 1924. *Dendroctonus jeffreyi* attacked the lower side of occasional logs during the seasons of 1923, 1924, and 1925, but did not become noticeably abundant until 1926.

Distribution and Character of the Infestation in Standing Trees.

No damage beyond that due to endemic infestations appeared on or around the windfalls until the autumn of 1924. In August and September of that year thousands of trees above pole size were top-killed by *Ips oregoni*, and large groups of small trees were entirely killed by the same bark-beetle. This damage occurred on, or near, the areas of heaviest windfall. This outbreak was limited entirely to the fall attacks of the 1924 season and, aside from the top-killing injury, it did not result in serious losses of mature trees.

No *Ips* attacks of importance occurred anywhere on the area in 1925.

During the summer of 1925 the Jeffrey pine beetle attacked the lower trunks of many standing trees previously top-killed by *Ips oregoni*. The combined losses from *I. oregoni* and *D. jeffreyi* for the seasons of 1924 and 1925 were estimated at 6,000,000 board feet.

In 1926 the attacks of the Jeffrey pine beetle in standing mature trees were heavier than for any preceding season. This loss averaged more than 10 trees per timbered section and was widely distributed throughout the stand instead of being localized around the areas of heavy windfall.

A survey made in September 1927 indicated that the epidemic of the Jeffrey pine beetle was rapidly subsiding; the estimated losses for the 1927 season are very much less than those for either 1925 or 1926. The course of these infestations from 1922 to 1927 is shown in fig. 2.

Probable Causes of the Rise and Decline of the Epidemic.

In this case, as in the California area, insects coming from the favorable breeding ground of wind-fallen trees were the largest contributing factor to the outbreak in standing timber. There was, however, a radical difference in both the character and timing of the outbreak. A short-lived *Ips* outbreak occurred the second season after the storm, much as the epidemic of the western pine beetle developed in the Yellow pine type on the California area. The *Ips* epidemic, however, was followed by a more gradual but sustained increase of the Jeffrey pine beetle, which

reached its peak the fourth season after the blowdown. Its decline was equally as sudden as that of the *Ips* and western pine beetle outbreaks.

The decline of the *Ips* outbreak was apparently due to the failure of these insects, after attacking the standing trees, to develop new broods equivalent in numbers to the number of parent beetles. That the out-

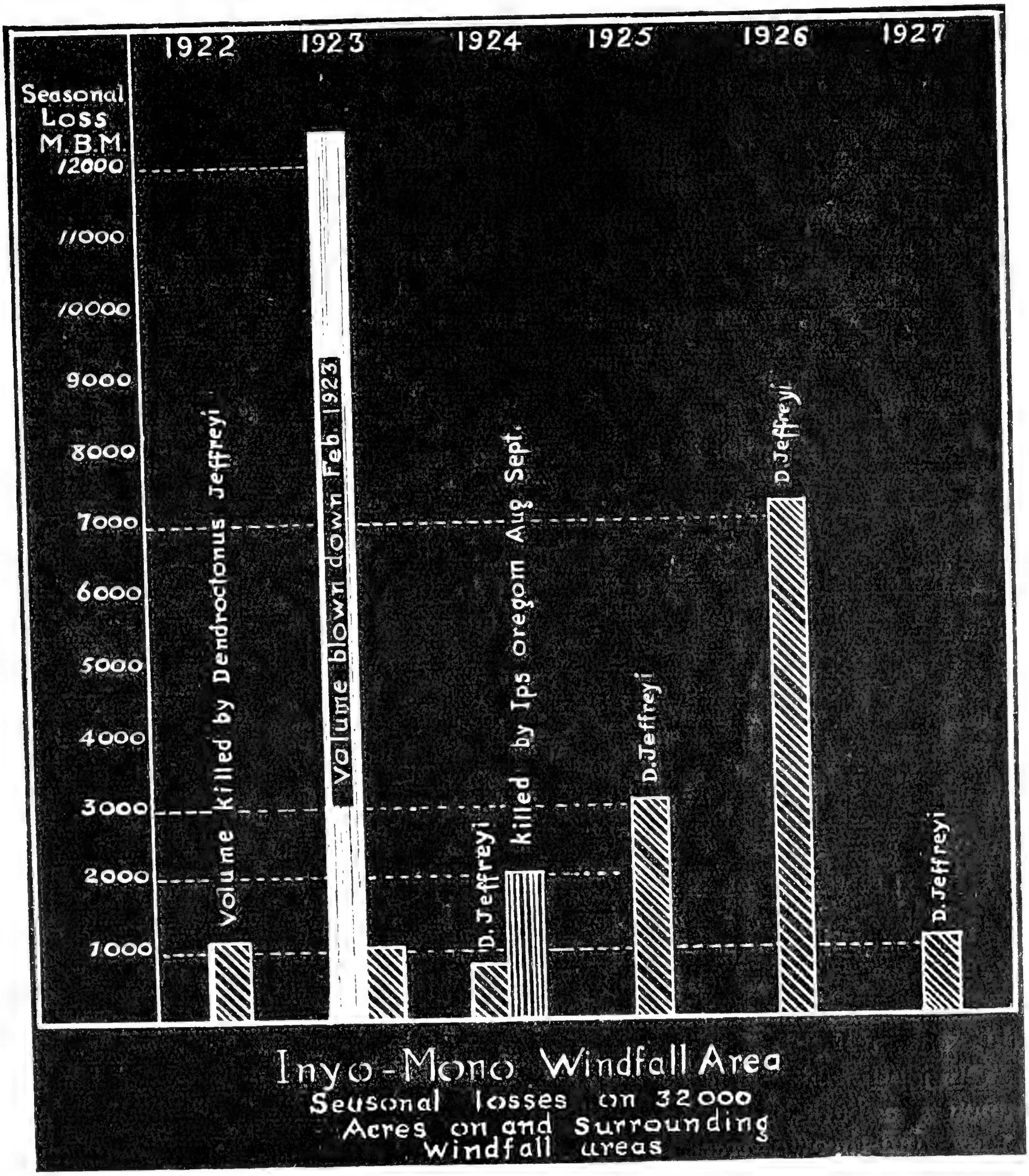


Fig. 2.

break of *D. jeffreyi* also subsided from the same cause is shown by the unusual number of trees on the area that had successfully "pitched out" or resisted attack. Still another factor in the decrease of *D. jeffreyi* was the increase of certain species of roundheaded borers which closely followed the bark-beetles in attacking the trees. The roundheaded larvae

developed rapidly enough to deprive the bark-beetle broods of their normal food supply in the inner bark, resulting in a high mortality of the latter.

POSSIBILITIES OF CONTROL OR SALVAGE TO PREVENT INSECT EPIDEMICS.

The loss resulting from unusual and violent windstorms in virgin timber stands can not be prevented and the risk of it must always be accepted as a hazard by the owner. Not only the loss of the wind-thrown trees, but the setting up of conditions that greatly increase the fire hazard and the possibility of insect losses, must enter into the liabilities. The matter of salvage or control measures, with the object of reducing both the fire hazard and insect menace, can therefore be considered with profit.

In any serious windfall situations that may develop the owner has three possible lines of action to consider in the protection of the values at stake. They are:

(1) To let conditions stand, accepting whatever subsequent losses may develop, and depending upon nature to work out finally an adjustment of the disturbance;

(2) To apply artificial control measures, with the object of preventing insect losses in standing timber; and

(3) To utilize the wind-thrown logs in order to secure whatever salvage is available from this material and at the same time remove a fire and insect menace.

The first course is probably the best one to pursue where timber values are so low that the cost of control or salvage work would exceed the probable value of the timber that would be saved. In fir stands, where there seems to be little probability of subsequent insect outbreaks, control work for the removal of an improbable menace would be of no advantage.

The application of bark-beetle control measures to the infested down logs would offer some advantages in mature pine stands where heavy losses of valuable stumpage are likely to develop from windfalls. Certain methods of control which require the burning of limbs and bark during the winter season would also reduce to a great extent the fire hazard within the area.

Obviously the point of attack where control would be most useful is upon the bark-beetle infestations while the insects are still breeding in the wind-thrown trees. However, in the conditions that ordinarily exist in recent windfalls the application of control measures offers certain disadvantages. The searching out of the infested down logs would require intensive strip methods, as they are not visible from a distance as are standing infested trees. The distribution of the broods within the logs is irregular, and a large percentage develop only occasional patches of infested bark. Compared with the infestation in standing trees, a much larger volume of timber would have to be treated to kill the same number of beetles.

Salvage operations seem to offer the greatest advantages where values are high and there is an available means of utilizing the fallen material. If the logs are removed from the area before the bark-beetle broods can emerge, no special control methods are necessary. If, however, they must be left in the area until after the time of emergence, control measures should be applied while the broods are still in the logs.

In the case of either control work or salvage operations, a clean-up should be completed within two seasons after the occurrence of the windfall in order to head off possible outbreaks in standing trees.

Prompt salvage of the fallen material appears to be the most feasible of all remedies to meet the fire and insect hazards connected with windfall situations. Even though the salvage operations cost more than the utilization value of the material, this course may prove profitable in the long run by preventing equal or greater losses resulting from uncontrolled insect outbreaks in the surrounding stands.

SUMMARY.

(1) Wind-thrown trees, owing to the fact that part of the root system remains in the soil, retain moisture in the inner bark, producing conditions favorable to bark-beetle attack and brood development. These conditions persist much longer in windfalls than in forms of slash in which the trees are cut down.

(2) Pine windfalls are especially attractive to bark-beetles. Where large masses occur in windfalls of this type, conditions are favorable for decided increases of the bark-beetle population, owing to the building-up of several generations in the down logs. These beetles may subsequently attack standing green trees on and around the windfall area.

(3) Two outstanding windfall areas in California have been studied in their entomological aspects.

- (a) In both situations studied, bark-beetle epidemics appeared with such suddenness in standing timber about the windfalls that their origin must have been largely the beetles coming from the wind-thrown logs. These epidemics subsided with equal suddenness after reaching their peak in the standing trees.
- (b) The period between the occurrence of the windfall and the bark-beetle outbreak in standing timber ranged from two to four seasons.
- (c) The type and composition of the stand apparently have much to do with its susceptibility to this attack. No epidemic at all occurred in Douglas fir, and the outbreak of *Dendroctonus jeffreyi* in Jeffrey pine developed much more slowly than that of *Dendroctonus brevicomis* in Yellow pine.
- (d) The sudden decline of epidemic conditions soon after the beetles went into the standing timber was due to a complex of causes. In the main, it is evident that bark-beetle epidemics built up by special conditions such as those in windfalls can not maintain their momentum after the beetles attack stands that are not naturally as susceptible to these infestations.

(4) The insect menace arising from heavy windfalls in the pine type may be reduced either by measures for bark-beetle control or by prompt salvage of the wind-thrown logs. Control work would be most useful if applied before the epidemic developed in the standing trees. Owing to certain difficulties involved in treating bark-beetle infestations in down logs, control would be profitable only in susceptible stands of high value. Salvaged material should be moved out of the area or else treated by approved control methods before the beetles can emerge from the down logs. Either control or salvage operations should be completed within two seasons after the windfall occurs, in order to prevent insect outbreaks in standing timber.

The Regional Museum and one of its Problems.

E. P. Van Duzee, Academy of Science, San Francisco, California.

The few words I have to say will concern entirely the entomological museum and should be so understood. The problem of the distribution of such museums and of their support is the same in all countries.

There seems to be two schools of museum workers: those favoring the centralizing of all museum facilities and those who favor the regional museum. If carried to its logical conclusion, the former plan would give us one complete world museum, at the British Museum in London possibly, while the latter would give us a museum for each city or center of population large enough to support a museum. For this discussion I will confine myself to the United States, and, living as I do on its perifery, I naturally favor the regional museum. I can see two very good arguments for the regional museum: first the great distances many students would have to travel in this country to use a centralized museum, especially where placed as is ours at one extreme border, and the consequent high cost of transportation, and second, the stimulus a local museum would give to the study of science in its neighborhood. The one and only advantage in a centralized museum is that one who could afford to travel to such a museum and to remain there long enough to complete his investigations, would find all available material at his hand.

Assuming as I do that the regional museum is best, the question arises how large an area should such a regional museum serve, in other words, how many such should there be in the United States, for instance. Off hand I would suggest that each state should establish and support such a museum, and it occurs to me that the state Agricultural Experiment Stations would as a rule be the best location for such a museum, except, perhaps, in a few states where other institutions, already established, are properly equipped to do the work. A number of states already have excellent collections now available for the nucleus of such a museum. Such are the collections of the Illinois Natural History Survey, that of the University of Kansas at Lawrence, and of the University where we are now meeting, and the collection at the Philadelphia Academy of Natural Science and that at the California Academy of Sciences. There are many others nearly or quite as good.

The first effort of such a museum should be to secure as complete a representation as possible of the insects of its own state, but beyond that they should endeavor to accumulate a general collection of insects, as complete as possible, so the student in that state could have a sound basis at hand for his systematic work. A general collection covering more or less completely the world fauna is essential to monographic work. Such museums should receive state funds and be kept from political control as strictly research institutions, and this brings us to the second part of our subject — the "one problem" indicated in the title of this paper, that

of state and federal support. The Division of Entomology of the Department of Agriculture now receives generous financial support from the federal government. For some reason it has been assumed, and probably with good reason, by those controlling the expenditure of these funds, that they must be expended entirely, or almost entirely, for insect control or for life-history work directly related to control measures; that the building up of a systematic collection of insects for the purpose of identification of material would be considered by the members of Congress who vote the department funds to have no relation to the proper government work of insect control. This view is absolutely erroneous. It is just as much the duty of the federal and state governments to determine the proper name of the insect that is troubling the agriculturist as it is to tell him how to control it. In fact it is the first step he has to take in the control of the pest, for, until he can learn its name, he is quite at sea. When he has learned the correct name he can, in most cases, turn to state or government bulletins and learn the control measures. And how does this work out under our present system where all the funds go for control and none for taxonomy? The farmer sends a specimen of his pest to the Experiment Station and asks for its name. The staff at the station is not certain of its identity and sends it on to some specialist, and this specialist, who has acquired his knowledge in his own private time and at his own personal expense for books and material, sends the name of the pest to the Experiment Station. By this beautiful system the government gets the principal and most important part of its information free of cost. If this system were followed in other departments of our government, the federal and state budgets could be very materially reduced. It is my claim that it is just as much the duty of our government, state and federal, to supply determinations for its citizens as it is to furnish information regarding control measures. Our congressmen are, as a rule, intelligent and reasonable beings and if the importance of accurate determinations could be properly presented to them, they would be just as generous with the taxonomic as with the control work. A proper staff of systematists should be installed at the National Museum and in the State Museums, where we have them, whose duty it should be to make determinations, not only for their field men, but for the farmers and private students, and such determinations should include the return of the specimens to the senders. With a system of state museums most of the work for private individuals could be done by them and the time of the National Museum staff could be devoted to building up a great systematic collection worthy of this country, and helping the state museums and its field men.

My plea then is for a system of State Museums and a central National Museum with staffs of state-and federal-paid systematists who may be in a position to make determinations for agriculturists and private students of insect life. The day has passed for our government to sponge one half of its entomological activities from overworked private students or privately supported museums.

Studies on the Etiology of European Foulbrood of Bees.

A. G. Lochhead, Division of Bacteriology,
Central Experimental Farm, Ottawa, Canada.

(With 8 text-figures.)

The investigations dealing with the subject of the etiology of European Foulbrood of bees, of which the present paper deals with one phase, are still in progress. The writer, therefore, would have ordinarily preferred to withhold communication of the present data until the project as a whole could be deemed complete. Owing to somewhat unusual circumstances, however, a preliminary communication (5) was made necessary, and for that reason it seems justifiable, on the occasion of this Congress, to discuss some of the results already obtained. The present paper deals more particularly with morphological studies of *Bacillus alvei.*

The question of the etiology of European Foulbrood is still an unsettled problem. *Bacillus alvei,* first described by Cheshire and Cheyne (2) in 1885, was formerly considered to be the exciting cause of what is now recognized as European Foulbrood. Carefully conducted inoculation tests with pure cultures of this organism, however, conducted by later investigators, notably White (9), did not lead to the production of the disease in experimental colonies, and it is now generally assumed that *B. alvei* as ordinarily encountered plays a secondary rôle in European Foulbrood. The organism may, however, according to Sturtevant (8), exert a marked influence upon the course and characteristics of the disease without having actual powers of pathogenicity.

That European Foulbrood is an infectious disease was definitely established by White (l. c.), who demonstrated that brood can be infected by feeding a suspension of crushed larvae sick or dead of the disease. This investigator attributes the disease to an organism which he named *Bacillus pluton,* a short rod or elongated, lanceolate coccus, commonly noted in microscopic preparations from diseased larvae, particularly in the early stages. The claim of White, however, may be said to be based on purely indirect evidence, on the basis of microscopical examination and inoculation tests with impure cultures, *B. pluton* apparently not having been obtained in pure cultures, as it is said to be incapable of cultivation on laboratory media. The selection of *B. pluton* as etiological factor was derived by a process of elimination whereby the other organisms, associated with European Foulbrood, including *B. alvei, Str. apis* and others, were excluded by a series of inoculation tests. While direct proof of the existence and pathogenicity of *B. pluton* is still lacking, this organism is commonly stated to be the cause of the disease, although Borchert (1) and Lehmann

and Neumann (4) still emphasize the state of unclarity existing in this regard.

Having regard to the persistent association of *B. alvei* with European Foulbrood and the unsettled question of the pathogenicity of the lanceolate cocci likewise regularly found in diseased material, morphological studies were made in the light of the modern bacteriological conception of pleomorphism. The old bacteriological doctrine of fixity of form in bacteria and limitation of reproduction to fission is giving way before the increasing accumulation of evidence showing that bacteria are capable of cultural and cytological transformations with capacity for other modes of reproduction than by fission, all pointing towards the existence of life-cycles. Although this newer conception represents a revolutionary change from the doctrine of monomorphism which still persists in many quarters, yet it has been shown that a coccus is not necessarily always a coccus, nor a rod-shaped cell always limited to the production of similar rod forms. Studies were therefore made with *B. alvei* to note particularly the existence of a coccoid stage in the life-history of this organism and the possible connection of this stage with the etiological factor in European Foulbrood.

As ordinarily cultivated on the common laboratory media, *B. alvei* forms at first moderately long, straight vegetative rods which, however, readily produce endospores. Characteristic of this organism is the tendency for the spores to arrange themselves in long rows, side by side (text-fig. 1). With such cultures, grown on ordinary nutrient agar, or on media containing yeast, spore formation is prompt and further morphological changes comparatively rare. On media containing sugars particularly, spore formation is greatly suppressed and may be quite absent on repeated transfers, especially on media without meat extract.

Cultivated on a medium which is composed of peptone 1 %, K_2HPO_4 0.05 %, dextrose 0.5 %, saccharose 0.5 %, agar 1.5 % (pH = 6.8), the tendency to form endospores is suppressed and the organism shows (text-fig. 2), at the same age as the culture seen in fig. 1, vegetative rods only, while the macroscopic appearance of the culture is different, being more transparent. After usually two weeks' incubation at room temperature, microscopic examination shows the rods in what is apparently a state of disintegration. Many of the rods stain much more faintly and lose their identity as they coalesce into an amorphous mass (symplasm). This stage is shown in fig. 3.

A further developmental change has frequently been observed which is also evident macroscopically. In 2 to 5 weeks old cultures secondary colonies have been observed on the thin, transparent, spreading *B. alvei* growth, which in certain areas becomes at first somewhat rough and finally shows a finely dotted growth, much suggestive of *Streptococcus* cultures. Microscopic examination of such areas shows the appearance in various stages of small coccoid bodies emerging from the symplasm (text-fig. 4), and which appear to be identical with the "regenerative bodies" described by Löhnis and Smith (6) in connection with other species. The coccoid bodies become later better defined and assume a shape and grouping (see fig. 5) which cannot be distinguished microscopically from the coccoid bodies assumed to be *B. pluton* in preparations made from foulbrood material.

The earlier attempts to stabilize this coccoid form of *B. alvei* were unsuccessful, its separation by transfer or replating having resulted either in a return to the original rod form or a failure to grow. Later trials, however, were successful in cultivating the coccoid form on the medium described above, and its stabilization in this form (fig. 6). Stabilization of a coccus from a bacillus type has already been reported, notably by Löhnis and Smith (7) for *Azotobacter,* and by Cunningham and Jenkins (3) in the case of *B. amylobacter.*

Fig. 1.

Fig. 2.

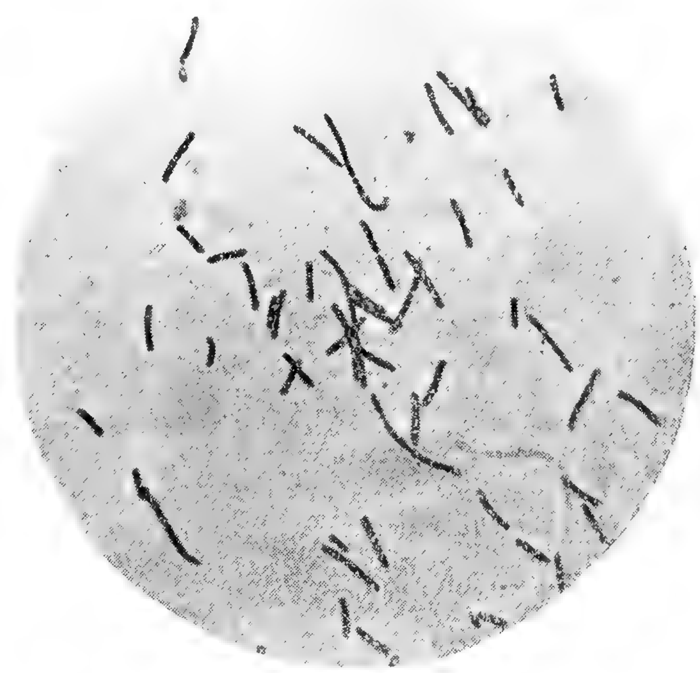


Fig. 3.

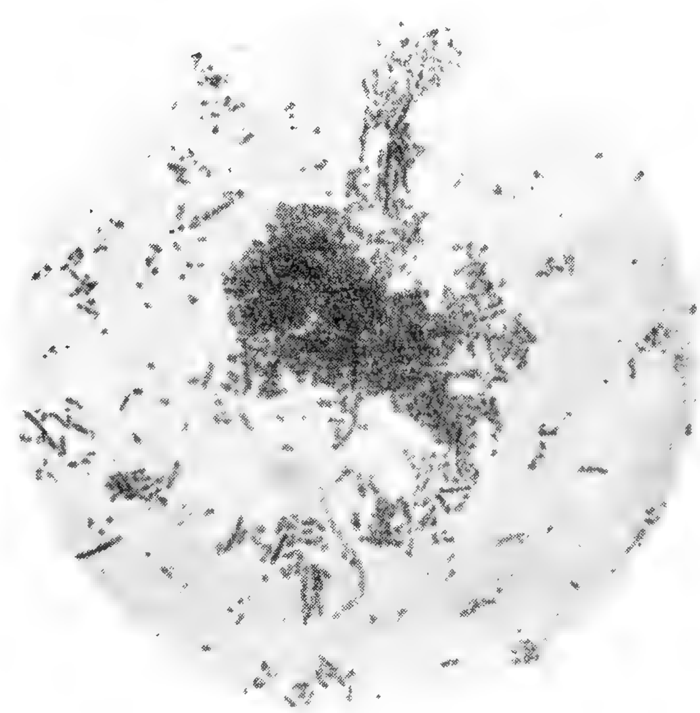


Fig. 4.

Fig. 1 — *Bacillus alvei,* vegetative rods and endospores, typical of growth on ordinary media, showing characteristic arrangement of spores.

Fig. 2 — *B. alvei,* vegetative rods on peptone-phosphate-dextrose-saccharose agar, 4 days; spore formation suppressed.

Fig. 3 — Rod forms fading and disintegrating as they lose their identity in coalescing into an amorphous stage (symplasm), 12 days.

Fig. 4 — Formation of small coccoids (regenerative bodies) from symplasm, 2 weeks. Magnification in all cases × 1000.

Fig. 5.

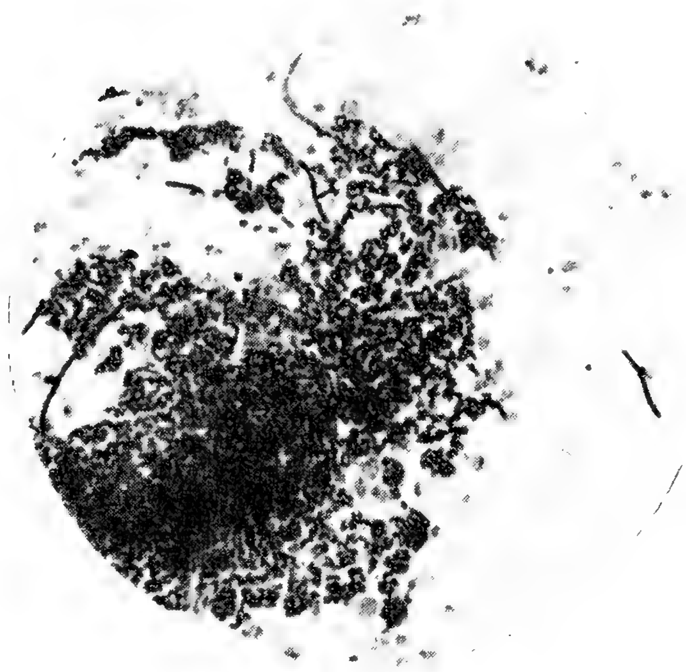


Fig. 6.

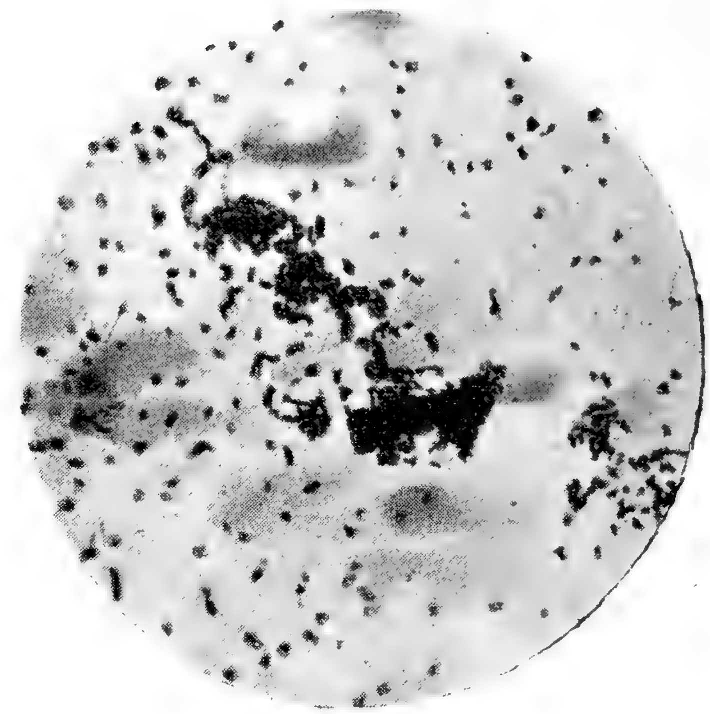


Fig. 7.

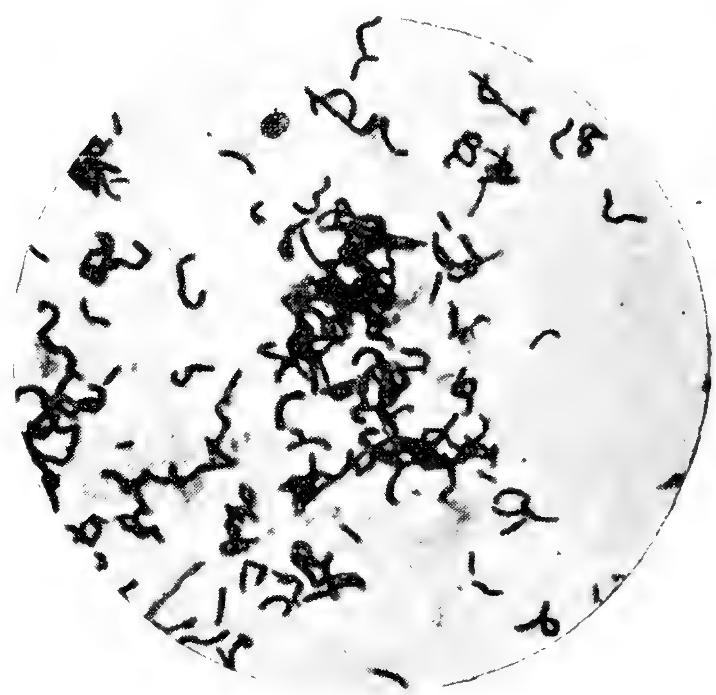


Fig. 8.

Fig. 5 — Fully formed coccoid or oval cells from 3-weeks culture of *B. alvei.*
Fig. 6 — Stabilized coccoid form from *B. alvei* culture.
Fig. 7 — Coccoid from *B. alvei.* Large coccoid bodies giving rise to rod forms by germination; 17-days culture in 5 % dextrose medium.
Fig. 8 — *B. alvei,* curved rods from anaerobic culture in medium containing yeast, honey and peptone.

Magnification in all cases × 1000.

The coccoid form of *B. alvei* is itself capable of interesting morphological variation depending upon the environment. When grown in more concentrated sugar solutions it shows a pronounced tendency to form large coccoid cells which themselves have the ability to produce rods by germination. In fig. 7, from a 17-days culture in 5 % dextrose, semisolid medium (agar 0.15 %), large coccoids are seen giving rise to rod forms.

As yet, the identity of the coccoid form of *B. alvei* with the coccoids seen in European Foulbrood is suggested only on the strength of microscopic comparison. Both are Gram positive, may assume lanceolate shape and may have similar group arrangement. Our attempts to produce the disease in a

colony of black bees through feeding cultures of the coccus have so far been inconclusive, and consequently no statement can be made at this time regarding the pathogenicity of this form of *B. alvei.* The point which the writer wishes to bring out on this occasion is that the bacillus of Cheshire and Cheyne, at present not considered to be a factor in causing the disease, possesses a coccoid stage which has all the appearance of what White calls *Bacillus pluton.* Is it possible that the views of these investigators may be reconciled?

Literature.

1. Borchert, A. 1926. — Die seuchenhaften Krankheiten der Honigbiene, p. 12. Berlin, Richard Schoetz.
2. Cheshire, F. R., and Cheyne, W. W. 1885. — The pathogenic history and history under cultivation of a new bacillus *(B. alvei)*, the cause of a disease of the hive bee hitherto known as foul brood; in Journ. Roy. Micros, Soc. Ser. II. Vol. 5, pt. 4 pp. 581—601.
3. Cunningham, A., and Jenkins, H. 1927. — Studies on *Bacillus amylobacter* A. M. et Bredemann; in Journ. Agr. Sci. 17, pp. 109—117.
4. Lehmann, K. B., and Neumann, R. O. 1927. — Bakteriologische Diagnostik, Band II, p. 236.
5. Lochhead, A. G. 1928. — The etiology of European Foulbrood of bees; in *Science*, 67 pp. 159—160.
6. Löhnis, F., and Smith, N. R. 1916. — Life Cycles of the bacteria; in Journ. Agr. Re. 6 pp. 675—702.
7. iid. 1923. — Studies upon the life cycles of the bacteria — Part II: Life history of Azotobacter; ibid. 23 pp. 401—432.
8. Sturtevant, A. P. 1925. — The relation of *Bacillus alvei* to the confusing symptoms in European Foulbrood; in Journ. Econ. Ent. 18 pp. 400—405.
9. White, G. F. 1912. — The cause of European Foulbrood; in U. S. Dept. Agr-Bur. Ent. Circ. 157.

Variability of the Honeybee Tongue biometrically investigated, and Practical Questions connected with the Problem of the Selection of the Honeybee.

W. W. Alpatov, Fellow of the International Education Board, Department of Entomology, Cornell University.

(With 6 diagrams and one map.)

The problem of the variability of bee tongues is not new in apiculture. In the first years of this century the leading American beekeeper's magazines discussed it with great enthusiasm, and the A. I. Root Company devoted to it a great deal of attention. During the years 1900 and 1901 every number of "Gleanings in Bee Culture" contained articles connected with this question. The so-called red clover long-tongued bees became world known. Queens which could produce extremely long-tongued bees were sold for twenty-five dollars and more. But little by little the agitation dropped and in the present American beekeeping this question does not exist at all. The outcome of this question can be very easily explained by some perfectly evident reasons. Biometry, a branch of biology which is devoted to exact statistical investigation of biological problems, was in the beginning of its development in the first years of the century, when all the bee magazines were full with articles discussing the variability of bee tongues and could therefore not help beekeepers to solve the question which they discussed. In the year 1916 an article was published in Russian by Chochlov (a pupil of Prof. G. A. Koshewnikov, Moscow) which can be considered as a new step in our problem. Chochlov measured very exactly the tongues of bees of 6 races (2 Caucasian races, Italian, Carniolian, Middle Russian and South Russian-Ukrainian) and found differences between their average lengths. Several biometric indices were calculated, but their interpretation was given without sufficient experience. Prof. J. A. Philiptschenko (1918), in a special paper devoted to this question, recalculated many of Chochlov's data.

The attention of the author of the present article to the question of the variability of the honey bee was attracted by an article of Mr. A. S. Michailov's (1924), who pointed out that the tongue length of bees in the plain of European Russia changes from the North to the South, showing a regular increase to the South. Since that time I have collected material on a very large scale from all parts of Russia and the Caucasus. Many Russian experimental beekeeping stations put at my disposal rough data on measurements of bee tongues. The data obtained were worked out with the application of necessary biometrical methods. The number

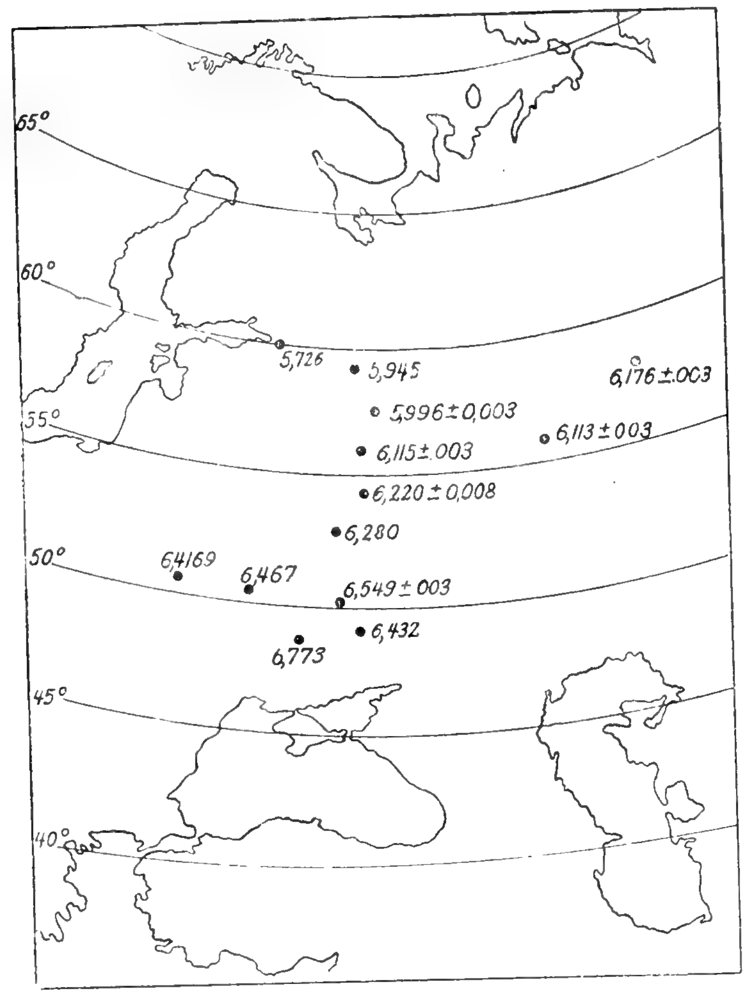


Fig. 1. Distribution of average tongue length (in millimeters) in European Russia.

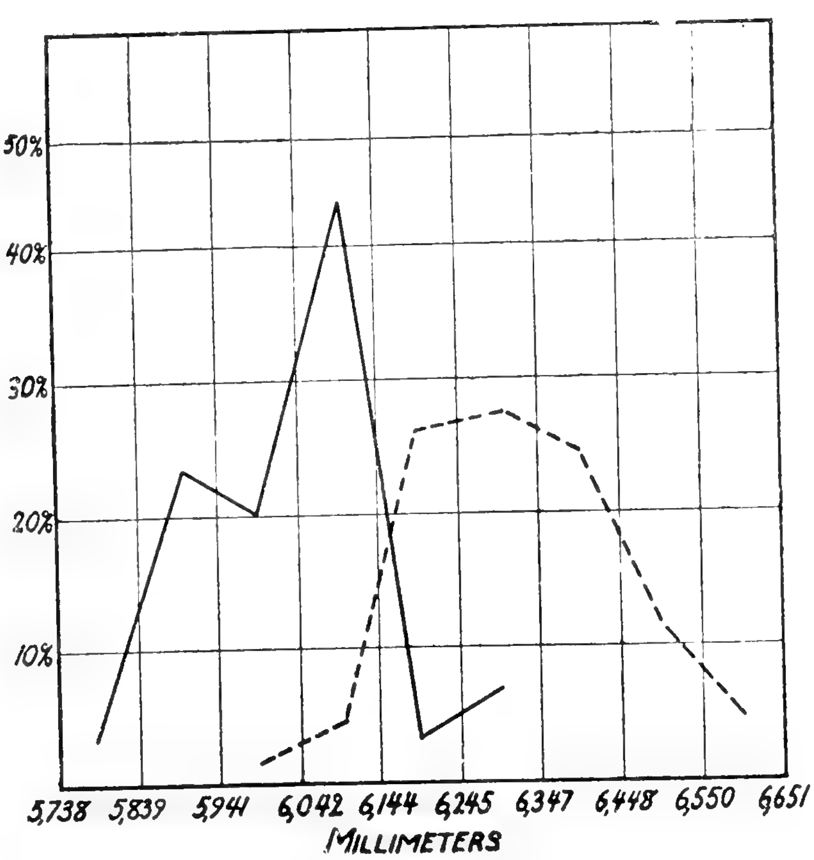


Fig. 2.

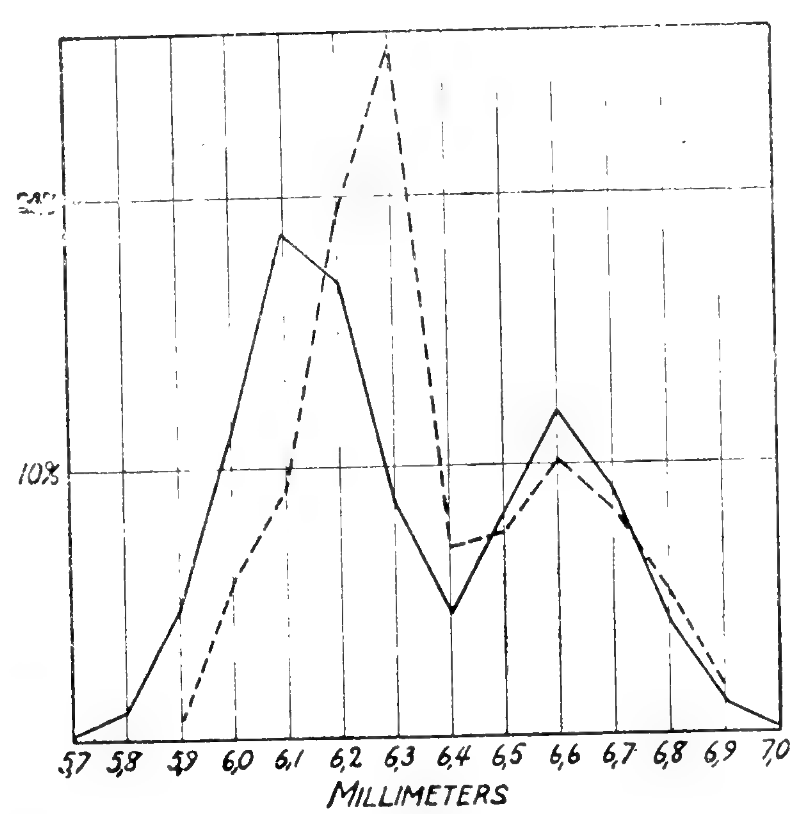


Fig. 3.

Fig. 2. Variation of tongue length. The continuous line represents bees taken from three colonies of native Moscow bees. The dotted line is based on measurements of bees from four colonies which one year before were transported to Moscow from a southern locality (Kursk district). The frequencies are expressed as percents.

Fig. 3. Tongue length variation of two groups of bees containing Middle Russian and Caucasian bees. The frequencies are calculated in percents. (See explanation in the text.)

of specimens of Russian bees (Caucasus excluded) upon which the conclusions are based is about 15,000. Text-fig. 1 shows the distribution of the average tongue length (in millimeters) in Russia. Taking into consideration the region which lies in the middle part of the country from which district most of the data were obtained, we find that the single deviation from the gradual increase of the tongue from the North to the South is represented by the number 6.432 mm. This exception can probably be explained by a very small number of bee colonies (3) from which the bees of the given locality were taken. Mr. A. S. Michailov, in his article (1924), suggested that the longer tongue of Southern bees is the result of an adaptation to some peculiarity in the nectar production of the flowers in the South. It is known from the old data of Bonnier that the nectar in the flowers in the South is situated lower in the corolla than in the North; hence the long tongue of the Southern bees is possibly adapted for nectar gathering from a greater depth.

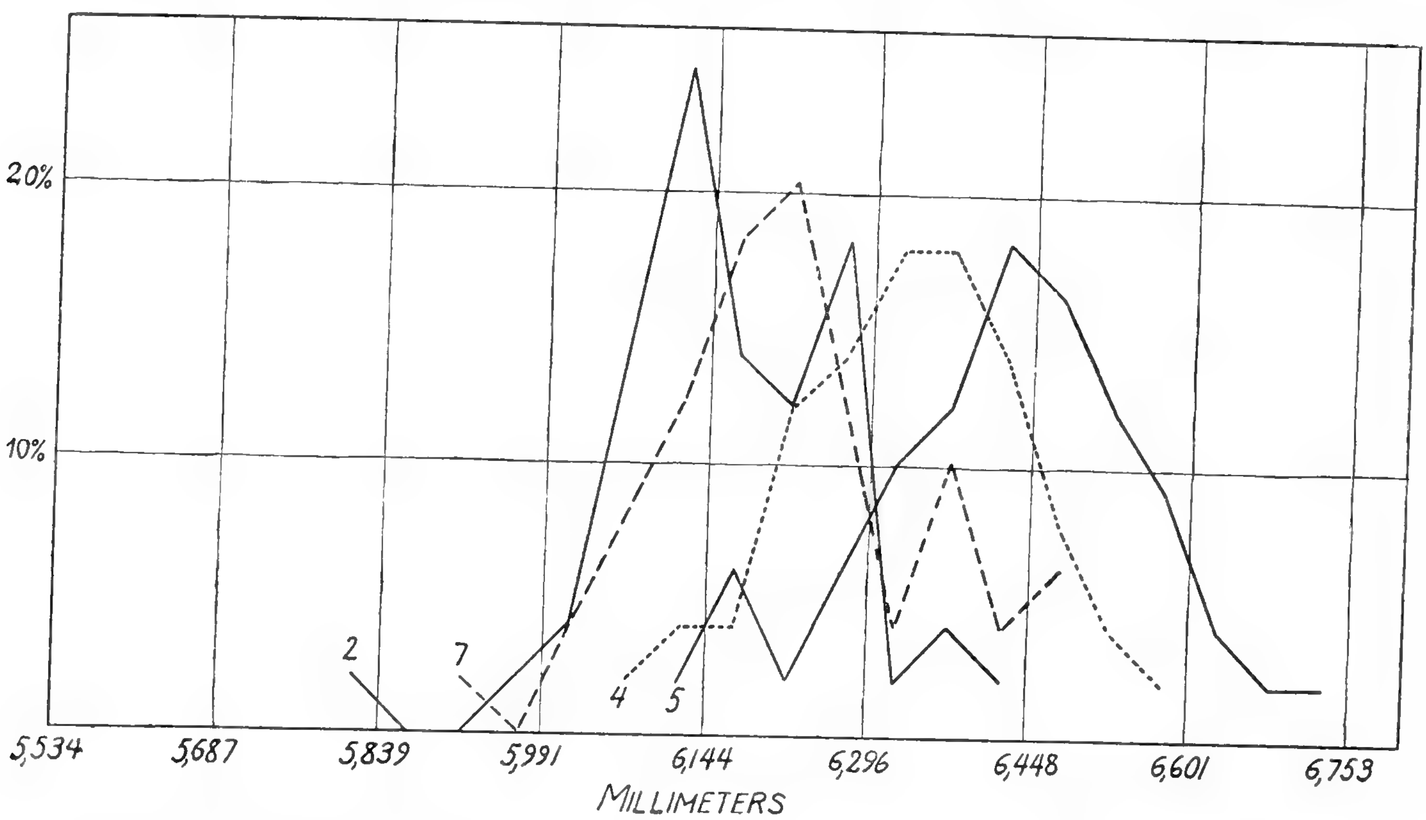


Fig. 4. Frequency distribution of tongue length of the Italian bee from different apiaries in U. S. A. (Curves 2, 4, 5, and 7, show the variations of bees from Kentucky, Alabama, Ohio and Ithaca. See Table 1.) The frequencies are expressed in percents.

From Chochlov's work the conclusion can be drawn that the tongue length of bees of different localities is an inherited character. I possess new material which shows this perfectly. The continuous curve (text-fig. 2) shows the variability of the tongue length of bees taken from 3 colonies of native Moscow bees (Middle Russia). The dotted line shows the variability of the same character taken in the spring of 1924 from 4 colonies which in the summer of the previous year were brought from South Russia (Kursk district) from a region with longer tongue length. It is very probable that the measured bees which were collected at the end of the month of May, 1924, were developed in Moscow. Nevertheless the average tongue length is longer than those of native Moscow colonies. The same conclusion can be drawn from text-fig. 3, the continuous curve representing the variability of bees taken from 19 colonies of Moscow bees. Some of these colonies a few weeks before were deprived

of their queen and received instead queens belonging to the Caucasian gray mountain race, which, as is known, has a longer tongue than the middle Russian race. In this colony a part of the bees belonged to the progeny of Moscow queens (left curve summit, average length about 6.1 mm), but there were already newly hatched bees of Caucasian origin and they gave the right summit of the curve.

Last summer I had the opportunity to measure gray Caucasian bees reared for many years in Colorado (U. S. A.) (text-fig. 5). They show practically the same length as the native Caucasian mountain bees. Working on biometry of bees in the United States of America I measured the tongue length as well as many other characteristics. Figures 4 and 5 and table 1 represents the results obtained.

Table 1

Averages and coefficients of variation of Italian bees from different apiaries 1—9 U. S. A and Italy, and of black bees in N. America. From each apiary not less than 50 bees were measured, taken from 10 colonies of each apiary.

		Arithmetical mean	Coefficent of variation
1	Pennsylvania	$6.324 \pm .009$	$1.50 \pm .10$
2	Kentucky	$6.166 \pm .011$	$1.78 \pm .12$
3	Alabama (apiary I)	$6.332 \pm .010$	$1.73 \pm .12$
4	Alabama (apiary II)	$6.340 \pm .010$	$1.63 \pm .11$
5	Ohio (apiary I)	$6.419 \pm .012$	$2.00 \pm .14$
6	Ohio (apiary II)	$6.396 \pm .013$	$2.05 \pm .14$
7	Ithaca, Cornell	$6.224 \pm .012$	$2.00 \pm .14$
8	New York	$6.388 \pm .010$	$1.63 \pm .11$
9	Italy	$6.234 \pm .010$	$1.69 \pm .11$
	Black bees		
10	Ontario, Canada	$5.960 \pm .013$	$2.27 \pm .15$
11	N. Carolina	$5.869 \pm .009$	$1.69 \pm .11$
12	Caucasian bees Colorado	$6.638 \pm .009$	$1.53 \pm .09$

In text-fig. 4 are shown the frequency distributions of bees from 4 American apiaries. The most interesting fact concerning the variability of Americanized Italian bees is that the length of the tongue is not uniform in different apiaries. The apiaries from Kentucky give only $6.166 \pm .011$ mm and the two apiaries from Ohio show the highest length, $6.419 \pm .012$ and $6.396 \pm .013$. The map (fig. 6) gives no indication of smaller size of the tongue of American yellow bees in the Northern parts of the country. It would be indeed difficult to expect such a rule, if we remember how many queens are sent every year from the Southern States to the North. The black bees which I succeeded in obtaining from Ontario and North Carolina show a very short tongue length and also no geographical regularity as do bees in Russia. Before beginning my measurement of American black bees I thought that they might show some differences in the North and in the South. It seemed easy to imagine that the black bees imported years ago to the U. S. A. would have become differentiated according to natural conditions in the South and in the North. Perhaps it would be better to postpone our final conclusion to a time when more black bees can be measured. Comparing the tongue of

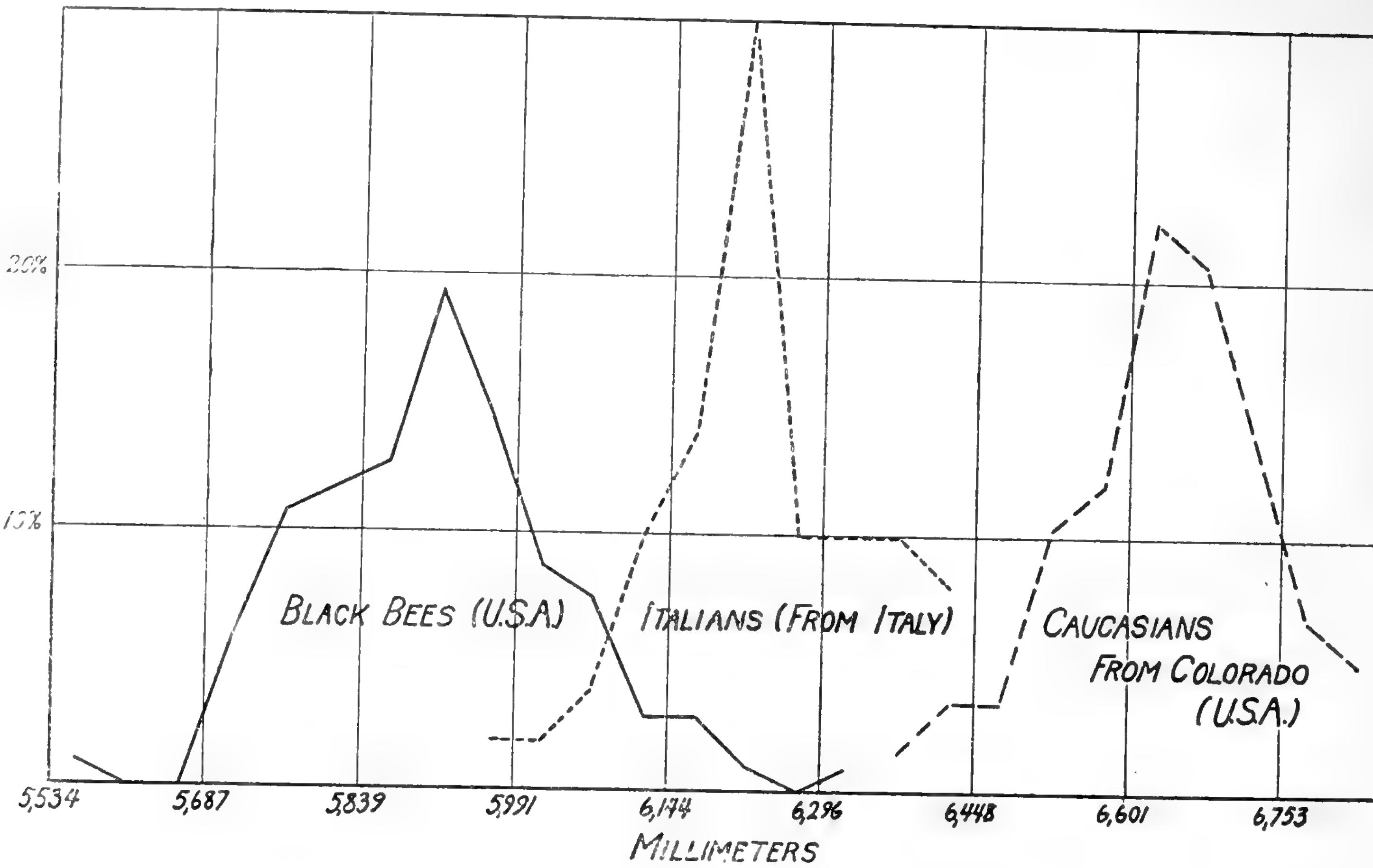


Fig. 5. Frequency curves of the tongue length of black bees and Caucasian grey bees in U. S. A., and of Italian Bees in Italy.

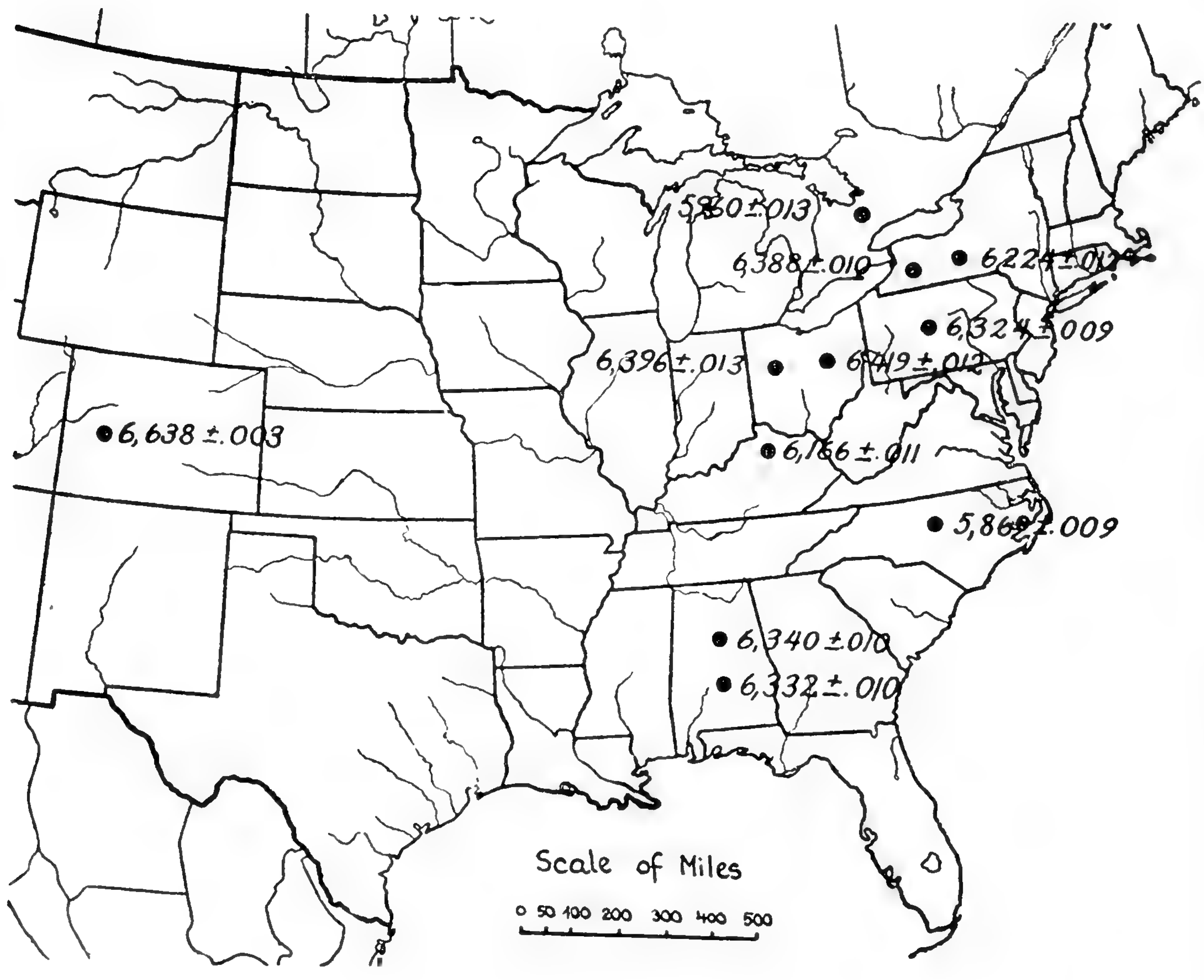


Fig. 6. Distribution of average tongue length of yellow and black bees in the United States.

the Italian bees reared in the United States with the native Italian bees we see that some American apiaries show a longer tongue than do the Italians and one apiary (No. 2) on the contrary a shorter one. But generally speaking it seems that the American Italians have a longer tongue. Unfortunately my experience with tongue length of Italian bees reared from pure Italian queens in Italy or in other places is limited to two cases. The first concerns measurements of bees received directly from Italy (see table 1). The second case concerns the progeny of pure Italian queens imported to North Caucasus. The second case gave an average length of tongue which did not exceed 6.300 mm. It is interesting to note that the gray mountain Caucasian bees, according to the data obtained up to the present moment, have the longest tongues of any of the bee races.

After giving the general picture of the tongue length in different races we can go into detail concerning, first, the variation of the tongue length in the limits of a given apiary; second, the connection of the tongue length with some qualities of bees connected with honey production.

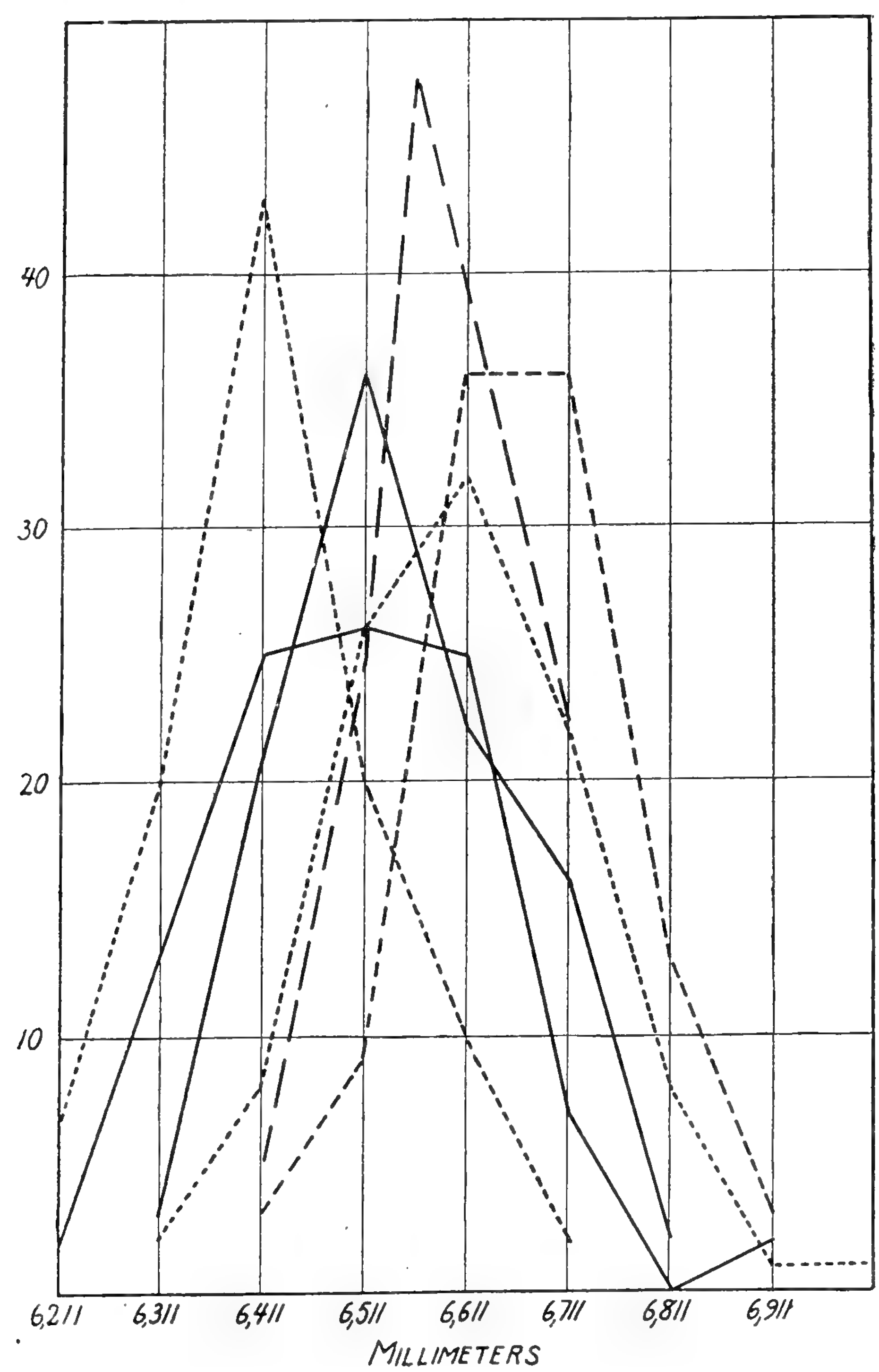


Fig. 7. Variation curves of the tongue length of six colonies from Kharkof Experimental Agricultural Station.

Text-fig. 7 gives the frequency curves of bees belonging to six colonies of the Kharkof experimental apiary (Ukraina) where the bees were measured and the measurement sent to me to be worked out. Table 2 is the basis for the construction of the curves of fig. 7:

Table 2

Frequencies of tongue length variation of 8 colonies of Kharkof bees; below Averages and Coefficients of Variation.

Numeration of colonies	20	1	3	21	9	7	2	8	Sum
7.061	—	—	—	—	—	—	—	—	—
6.961	—	—	—	—	—	—	1	—	1
6.861	—	2	—	—	—	—	1	3	6
6.761	—	0	—	1	2	—	8	13	24
6 661	2	7	3	11	16	22	22	36	119
6.561	9	25	19	29	22	48	32	36	220
6.461	20	26	51	36	36	25	26	9	229
6 361	43	25	24	22	21	5	8	3	151
6.261	20	13	3	1	3	—	2	—	42
6.161	6	2	—	—	—	—	—	—	8
M	6.423 ± .007	6.501 ± .009	6.506 ± .006	6.541 ± .007	6.544 ± .008	6.598 ± .005	6.608 ± .007	6.667 ± .007	6.549 ± .003
C %	1.68 ± .08	2.06 ± .10	1.30 ± .06	1.52 ± .07	1.72 ± .08	1.22 ± .06	1.47 ± .07	1.53 ± .07	1.95 ± .03

We can see that the averages of single colonies differ considerably. For many animals it has been shown that the differences between the families are hereditary. Judging by analogy it may be supposed that in the differences in bee colonies heredity plays an important role. Of course we must bear in mind also that the condition of development (temperature, food, size of comb cells) have certain influences on the organism of the bee. The hereditary character of differences in colonies gives us the possibility of applying selection of our material with success.

The second important question in the problem of selection is to find the relation between the external characters of the bee and this or that quality which is economically important. The observation of J. H. Merrill (1922) attracted great attention among beekeepers. This paper is valuable as a first attempt to solve the problem by means of exact numerical data. The fact is that there seems to exist a relationship between the size of bees of a colony and the total quantity of honey obtained from this colony, but it is not possible to consider this as proved. In order to prove this it would be necessary to have not 4—6 colonies, as was the case in Merrill's work, but at leasr 50—60 colonies and to work out the data by means of mathematical statistics.

Some very interesting conclusions can be drawn from the material published by Mr. W. P. Michailov, Director of the experimental farm of the Perm State University (Russia). This author measured the bee tongues in 23 colonies, taking about 200 bees from each hive. The

colonies were classified as strong, medium and weak. This classification has not, of course, the precision of a quantitative valuation, but nevertheless it expresses the general impression as to the quantity of bees in the hive, their degree of working activity, etc.

Table 3
Correlation of the average tongue length of the colonies and their strenght.

Strong	—	—	4	2	1
Medium	—	4	5	—	..
Weak	1	1	5	—	—
	6.05	6.10	6.15	6.20	6.52

In Table 3 is shown the relation between the length of the tongue of the bees and the vigor of the colony. It will be seen that the numbers contained in the squares ascend almost regularly from the left lower corner to the right upper one. Calculating the mean length of the tongues for colonies of different degree of vigor we obtain for the weak colony 6.153 mm, for the medium 6.153 mm, and for the strong 6.202 mm. A rule is evident: the stronger the family the longer the tongue. One can calculate the so-called coefficient of correlation. This coefficient is equal to 0.489 ± 107. Statistics teach us that we have 520 chances against one when we conclude that the connection obtained is not solely a result of chance. Applying Fisher's more modern method for testing the significance of an observed coefficient of correlation in a small number of cases, we have 50 chances against one. We may therefore conclude with tolerable certainty that the connection did not arise by chance alone, but has a deeper significance *). In discussing the statistical facts which I discovered it must be strictly kept in mind that we do not know what is the cause and what is the result in the correlation of the two phenomena. We do not know whether the family is strong because the bees constituting it have hereditary longer tongues or whether strong families breed bees with long tongues. Anyhow, the number here given is the first in the literature connecting the biological and economical character of the bee colony — its vigor with the external characteristics of bees constituting the colony.

I must warn the reader against the conclusion that the differences of different strains (apiaries) shown above are due to the vigor or weakness of the single colonies. The rule just described concerns the connection in the limits of a strain and cannot be applied to the interpretation of differences between strains. At the end of my article I must call attention to the dotted curve of text-fig. 3. Both curves of this diagram are based on data obtained by me from the Moscow Experimental Apicultural Station through the courtesy of the director of the

*) In a recently published paper (1927) A. S. Michailov has shown that there is no correlation between the size of the bees and the strength of the colony. His conclusions are based on the measurements of bees from 30 colonies of the Tula apicultural experiment stations. This disagreement from our conclusion based on data from Perm will perhaps find its explanation in the supposition that the Tula colonies were more uniform in respect to their strength than the Perm colonies. Anyhow, the question needs to be investigated further.

station, A. F. Gubin. The dotted line represents the variability of bees collected by the collaborators of the station on flowers of red clover. The bimodal character of the dotted curve like that of the continuous line can be easily explained by the presence of Caucasian bees in several colonies of the apiaries. The most interesting fact is that in the dotted line the summit which represents the black middle Russian bees working on red clover is situated a little to the right of the summit of Moscow black bees collected from hives. It means that the Moscow black bees which were collected during their work on red clover have a longer tongue than the general population of Moscow bees. In other words, only comparatively long tongued Moscow black bees can work on red clover. I believe that this discovery communicated by A. F. Gubin at a meeting of the representative of Russian Experimental Apicultural Stations (1927) is one of the most interesting facts from theoretical and practical points of view concerning the relationship between the honeybee and the flowers *).

Literature.

1. Alpatov, W. W., and Tjunin, F. A. 1925. — Beiträge zur Kenntnis der Variabilität der Rüssellänge bei der Honigbiene (in German, with Russian summary); in Rev. Zool. Russ., Bd. V, pp. 79—108.
2. id. 1925. — Über die Verkleinerung der Rüssellänge der Honigbiene vom Süden nach dem Norden; in Zool. Anz., Bd. 65, pp. 103—111.
3. id. 1926. — Der Rüssel der Kasaner Arbeitsbiene in variationsstatistischer Bearbeitung (in Russian, with a German summary); Bull. of Kasan Agric. Exp. Station, pp. 23—33.
4. id. 1927. — The cardinal problems in the study of the Caucasian bee races (in Russian); in Ptschelowodni Mir., V. 1, pp. 3—8.
5. id. 1927. — On the amelioration of the bee races (in Russian); in Ptschelowodnoje Djelo, 1927, N. 8—9, pp. 372—377).
6. id. (—) — On the variability of the tongue length of Caucasian gray bees and its inheritance (in Russian, with English summary); in press., Ptschelowodni Mir.
7. id. (—) — Biometrical study on bees of Middle and Southern Russia (in press, in Russian, with English summary); in Rev. Russ. Zool.
8. Chochlov, B. P. (1916). — Studies on the bee tongue length. Department of Agriculture, Petrograd, pp. 17—41 (in Russian, separate edition).
9. Koshewnikov, G. A. (1900—1905). — Materials to the natural history of the honey bee, Vols. I and II.
10. Loginov, W. T. 1926. — On the application of biometry to beekeeping; in Bull. of Kasan Agric. Exp. Station, pp. 1—22.
11. Merrill, J. 1922. — The correlation between some physical characters of the bee and its honey-storing abilities; in Journ. Econ. Entom., V. 15, pp. 125—129.

---

*) My work on American bees could be done thanks to the fact that I found in the laboratory of Prof. E. F. Phillips not only hospitable accommodation, but also permanent help and advice in my work. I desire to express to Dr. E. F. Phillips my deep indebtedness and thanks. At the present moment I am working in the Institute of Biological Research, under Director Prof. Raymond Pearl, corner of Wolfe and Madison Street, Baltimore, Maryland. Through the permission of Dr. Pearl I shall be able to work out further material on bee tongue length, provided the technical help in dissecting the bees will be paid by those who are interested in such measurements. I am also very grateful for the help that I have received from many beekeepers in this country who sent me material necessary for this investigation.

12. Michailov, A. S. 1924. — On the length of the tongue of bees from the Tscherepowetz District in connection with the size of bee tongues in different localities; in Ptschelowodnoje Djelo, February 1924.

13. id. 1927. — Is there any correlation between the strength of the bee colony and the size of its bees?; in Opitnaja Paseka, No. 11.

14. Phillips, E. J. (—) — Variation and correlation in the appendages of the honeybee (in press).

15. Philiptschenko, J. A. 1918. — La variabilité chez les abeilles et la statistique de variation; in Journ. Russe de Zoologie, V. III (in Russian, with French summary).

Some Remarks on the Keys of the European Chalcids.

J. P. Kryger, Gentofte, Denmark.

The zoological museums are year by year more handicapped. People have discovered that the museums are not only collections of dead animals, but also collections of living men who know all about animals which play a part in man's welfare. Numerous are the questions put to the museums, numerous are the objects sent to them for identification, and people ask for remedies against pests destroying their crops, etc. In my belief a man in a museum to-day is a person with a typewriter who can do nothing else but answer inquiries. No one asks for science.

One can hardly hope that the governments will appoint so many assistants for the museums that these assistants will have time enough for scientific work, and all we can expect is that in the course of time the work will be made easier for the museum's assistants. This has been done in the case of Lepidoptera. The collections of this order are rather complete in the museums and we have good books with good pictures of almost all species, so that it is not difficult to determine the species.

The worst group of all are the Hymenoptera. The pictures are scattered in numerous periodicals, the keys are deficient, often they are erroneous, and most of the museums have no well-determined collections. Especially is this the case with the Chalcid Flies.

First of all it seems to me to be necessary to issue a book with good pictures of the 3—400 European genera and to get good keys for them. This will not only be useful to the European scientist, but also to people in non-European museums, who would be glad to have such a book, as their genera are often the same as the European ones.

My friend Mr. Bakkendorf always says "stamps" when I mention this matter, and possibly many scientists will be inclined to join him: stamps! But I think that it should be made as easy to determine a Chalcid Fly as to put a stamp into its right place in the album. It would surely be better if it were so, better than it is now: a man — often an amateur, and often but one in all Europe — spends nearly all his life in unravelling the secrets of the Chalcid Flies, and when he is dead, some other person has to do the same work over again.

I am now going to say a few words about the European keys to the Chalcid Flies. The first authors were the best, but Haliday has only about 100 genera, Foerster about 180, and Thomson has only the Scandinavian species and his book, moreover, is written in Latin, a language which is being more and more forgotten. The fact that the keys of these authors are rather good testifies that these authors themselves had caught, or possessed, all their species. And notwithstanding this

they also may have made mistakes. Worst of all is that not one serious attempt has been made at arriving at a natural system. It is certainly convenient to divide the Chalcids into 4 groups: Pentamera, Tetramera, Trimera and Mymaridae. Foerster then divides the Pentamera into two sections:

1. with thick hind femora, and
2. without thick hind femora.

These hind femora cannot possibly be such a primitive quality as to deserve to be put first in the key. And later, on p. 18, Foerster writes about *Pirenoidea* and *Spalangoidea:* Antenna inserted just over the mouth, but on p. 41 we learn that he divides Spalangoidea into two sections:

1. with antennae inserted just above the mouth, and
2. antennae inserted for above the mouth.

And on p. 47 he says in the key: 2 anelli — *Macroneura,* one anellus — *Merostenus,* but on p. 50 he writes: of *Macroneura* and *Merostenus* I only have the males and both have one anellus. On p. 67 he says of *Selaoderma caprea* Walk.: male and female with 12-jointed antennae, and supposes it to be the same as *Tridymus* Ratzeb., which, in his own key p. 64, has 13-jointed antennae.

If we now proceed to a later author, Schmiedeknecht 1907: Die Hymenopteren Mitteleuropas, the matter is not any better. His attempt is perhaps the first to give us a key to all the European Chalcids, and it is clearly seen from his work that he has not examined all the insects himself, but has based his work mostly on the literature.

Schmiedeknecht is not a specialist in Chalcids and no one could expect that his attempt should be successful throughout. But to the author's praise it must be said that his work is efficient when, conjointly with his keys, you use Haliday, Foerster, Thomson, and others. And if I mention a few of his errors it is not for the sake of attacking him, but rather to make it clear that it is impossible for one single man to give a key to all the Chalcids, a task which must be undertaken in cooperation by several authors.

In the keys very often not the same characters are stated for comparison. It is said about one genus: "parapsidal furrows very distinct", but in the genus which is opposed to it nothing is said about the parapsidal furrows. In one place it is stated: "antennae 11-jointed" and nothing is said about annelli, while the alternative is "2 annelli". You read: "ovipositor short, postmarginal vein and stigma short"; but in the contrasted genera nothing is said about the veins.

Near the bottom of one key are mentioned the teeth of the mandibles. Why not mention them for all genera, and why not put them first in the key, as this dentition may surely be a primitive character? First in his keys Schmiedeknecht writes p. 448:

hind femora with 2 spurs . . . . . . *Microgaster.*
hind femora with 1 spur . . . . . . *Pteromalus.*

It surely is not of fundamental significance whether a species has one or two tibial spurs.

p. 469 Schmiedeknecht says:
Tridymus . . . 12 joints in antennae, but Foerster says both 12 and 13.

p. 473: — 32. Antennae 12 jointed (2 anelli) 34
Antennae 13 jointed (2 anelli) 35
But *Habritys*, which belongs to one of these groups, has 3 annelli.
p. 474: — 11. *Psilocera (Dichalysis)* . . . . 3 annelli
Foerster writes (p. 52 Hym. Stud.) *Dichalysis* . 2 annelli.
head . . ., antennae 12 jointed . . . . . . 93.
p. 480: — 64. head : 65

But when you go to 93 you find: Antennae 10 jointed. If you have no knowledge of these insects beforehand, it is impossible to know where the error is.

p. 485. — Antennae 10 jointed with 3 jointed club . . . *Teleogmus.*
But Foerster (p. 72. Hym. Stud.) has: antennae 9 jointed, 2 jointed club.

p. 482: — 27. Antennae 10 jointed . . . *Secodes.*
But Foerster says: *Secodes* has antennae just as in *Holcopelte:* 8 jointed with one jointed clavus.

p. 488: — *Pleurotropis* 10 jointed antennae, but Foerster says 8 (perhaps 9) joints.

Schmiedeknecht puts *Pyrenoideae* to *Miscogasterinae*, Foerster has the group near to the top of all *Chalcididae*.

Platynocheilus, which has 5 jointed tarsi, is put by Foerster to the *Cleonomyidae*. But Schmiedeknecht puts it to *Enlophidae* (with 4 jointed tarsi). *Rhaphiteles* is stated to have a thickened marginal vein, which is not the case. The matter has a quite different explanation.

Stenomesius is said by Ashmead to have 2 tibial spurs and by Thomson to have 1, and Schmiedeknecht puts it in his key p. 484 *(Enlophininae)* in two different places, which only throws the matter into confusion.

I shall not go on with this. I hope that I have given you enough examples for you now to understand that it is not at all an easy matter to determine European Chalcids. A German investigator who has written a book on the Tachinid Flies says in the introduction: a man who is going to determine Tachinid Flies must first try to get together a collection of well determined Tachinids before he can hope of getting on well with his own collection. It may equally be said that a person who wishes to determine Chalcid Flies must first try to get a collection of well mounted, and well determined Chalcids before he sets to work. But I think in both cases he will try in vain; no one will be able to-day to give him a good collection of well determined Tachinids or Chalcids.

Discussion.

A. B. Gahan: — The principal fault with the generic keys to the Chalcidoidea as given by Schmiedeknecht, Ashmead and others is that they are based too largely on the literature. Many of the early descriptions of genera, and not a few recent ones, are too short and lacking in the essential characters which we make use of today for

the separation of genera. Many others are inaccurate in details, such as the number of antennal joints, owing to lack of adequate facilities for the examination of specimens. The crying need of the hour, so far as the classification of the Chalcidoidea is concerned, is for the study of genotypes and accurate redescription of the older genera. By this I mean a redescription of the actual specimens upon which the genotype species was based, and not a redescription of someone's determination of that species, unless the determiner had really adequately compared his specimens with the types. In the course of a trip through several of the Museums of Europe during the fall and winter of 1927, I found in a number of cases several quite different insects going under the same generic names in the various Museums and in some instances still other forms going under those names in America. In my opinion it is much more important that these old genera be straightened out and accurately described than that new genera be added to the long list already extant. Not until this is done will it be possible to construct accurate generic keys for the Chalcidoidea.

J. R. de la Torre Bueno: — Mr. Kryger's paper has given a particular instance of a general practice. Our predecessors, while rejecting all superstitions, displayed a touching faith in the printed word and accepted implicitly whatever their contemporaries set forth, without question and without checking its correctness. In our day we meet perfectly competent Entomologists who seem to believe that, because they are familiar with a given group in all minute details, they are therefore competent to delve into any other group with finality. Some tackle entire groups alien in all respects to their line of competent authority; others dip into them sporadically; and both too frequently with unhappy results. For, indeed, it is an ungrateful task to correct a man who is a lovely friend and an intimate of his favorite group, but, alas, a sciolist in any other.

Remarks on the Morphology and Geographical Distribution of Neohydrophilus (Coleoptera, Hydrophilidae), especially the American Species.

A. d' Orchymont, Brussels, Belgium.

(With 9 text-figures.)

Entomologists of old admitted among *Hydrophilus* such species as *H. castus* and *H. obtusatus* Say from North America; more modern students, judging from the similitude of the outer aspect, are still inclined to consider these two forms as belonging to a single generic unity. I have shown in 1919 that this is an incorrect proceeding and based my opinion on morphological evidence. *Neohydrophilus castus* Say, as all other *Neohydrophilus*, differs from *Hydrophilus*, for instance *H. obtusatus* Say, in the following characters:

1°. Prefrons on anterior margin widely emarginate, the membraneous and yellowish or brownish preclypeus conspicuous in the emargination;

2°. Labrum anteriorly with two isolated pores, not much separated, in which there is a brush of short and stiff hairs;

3°. Posterior transversal row of setigerous punctures of labrum interrupted in the middle;

4°. Antennal club perfoliate and composed of very asymmetrical joints;

5°. Maxillary palp very long, with the last joint showing a tendency to equal the 3d in length;

6°. Claws of all tarsi strongly dentate at base in ♂♀, the basal tooth much more developed and spatuliform on anterior tarsi in the ♂; etc.

We must admire the accuracy of Say, who already in 1837 observed the two anterior pores of the labrum when describing his *castus*.

One of the aims of this paper is to show that generic separation of *Neohydrophilus* is also supported by the morphology of the male genitalia.

If we dissect a *Hydrophilus obtusatus* Say or a *H. caraboides* L., we find that the aedeagus is of the usually trilobe form of the simplest pattern (text-fig. 1: median lobe surrounded by the two parameres or lateral lobes, the latter inserted on the basal piece of which the ventral part forms a continuous sclerite). In *Neohydrophilus* the aedeagus is of a still more complicated nature. Firstly the median lobe is much more chitinized and bears points or spines disposed differently; second, in the basal piece the ventral slerite (belonging to the 11th sternite of the body) is accompanied

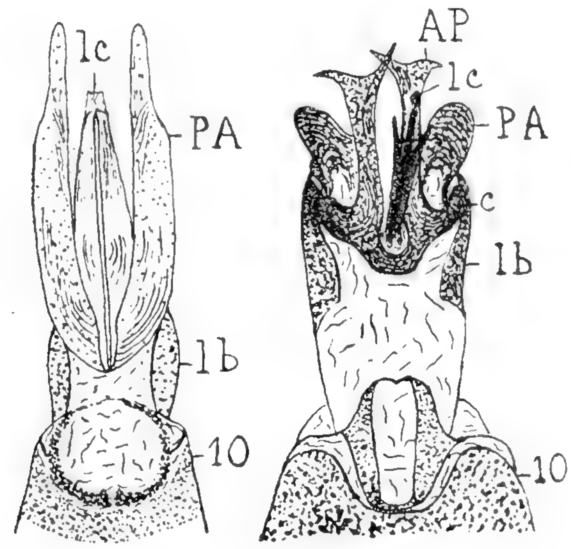


Fig. 1. *Hydrophilus caraboides* L. Fig. 2. *Neohydrophilus* sp. (African)

Dorsal view of aedeagus; 10:10th ureta; lb = basal piece; PA = lateral lobes; lc = median lobe; AP = paired dorsal appendages of basal piece in *Neohydrophilus*. Better as in most American species this African form shows very well relations existing between the appendages AP and the ventral sclerite of basal piece articulated by a sort of condyle c. In this species the lateral lobes are still separated from base of basal lobe by a connective membrane.

by a dorsal plate (belonging to 11th tergite) which is prolonged into a pair of appendages as long as the median lobe itself and of different shape and variously armed according to species. Furthermore, the lateral lobes have a tendency to differentiate along different lines. In American species (North and South) these lateral lobes are intimately reunited to the ventral sclerite of the basal piece. In some African species (perhaps all?) these lobes are not reunited to the basal piece, but articulated with it by means of a connective membrane (text-fig. 2).

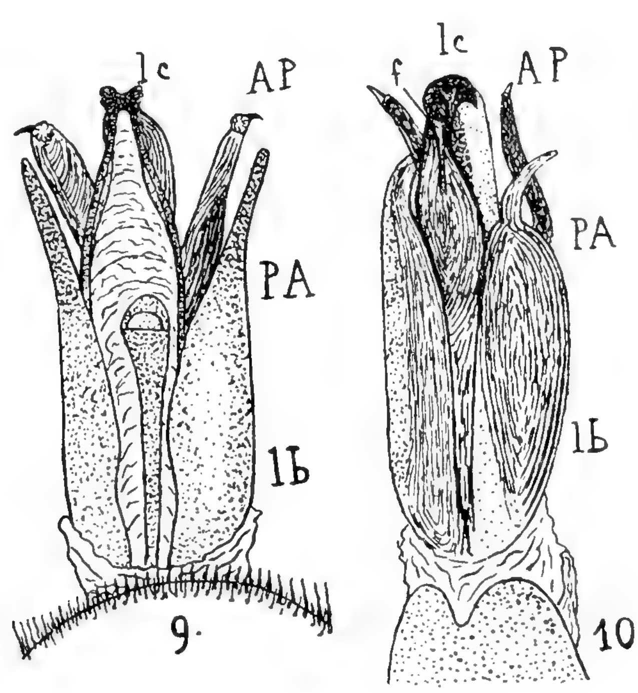


Fig. 3. *N. grandis* Casteln. Fig. 4. *N. medius* Brullé.

Ventral view of aedeagus.
Preparation sligthtly inclined to the left.
f: minute excavation at ventral extremity of median lobe.

The accompanying drawings of the aedeagus of the seven recognized American species of *Neohydrophilus* are sufficiently suggestive by themselves and a full description of each organ seems not necessary here. It may, however, be added that we have among them a first group composed of four species: *grandis* Casteln., *medius* Brullé, *phallicus* m. and *ignoratus* m. (text-fig. 3 to 6).

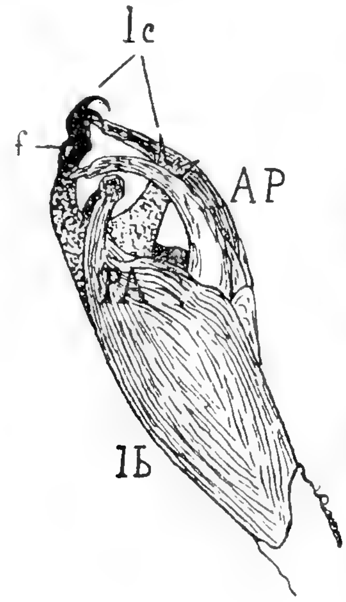


Fig. 5.
N. phallicus m.
Sideview of aedeagus.
f: minute excavation as above.

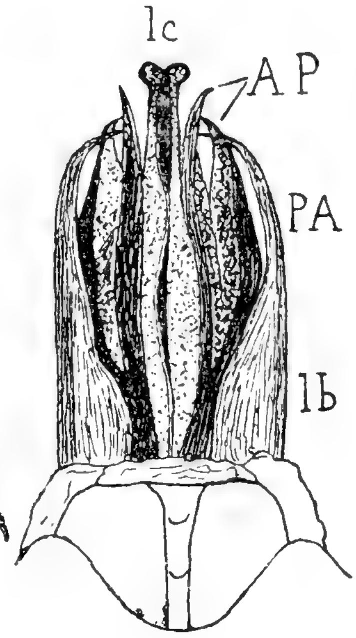


Fig. 6.
N. ignoratus m.
Dorsal view of aedeagus.
Preparation slightly inclined to the left.

In these the extremity of the median lobe is not deeply forked. A differenciation worthy of note occurs in *ignoratus:* the appendages AP are each for itself split into two long branches.

Two other American species, *N. longus* Bruch and *N. politus* Casteln. (text-fig. 7 and 8) have a deeply forked median lobe, but these species are nevertheless not closely akin.

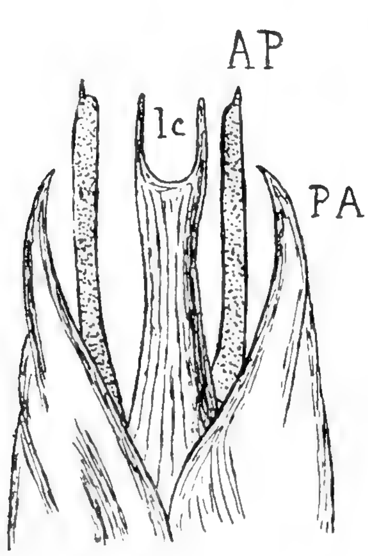


Fig. 7.
N. longus Bruch.

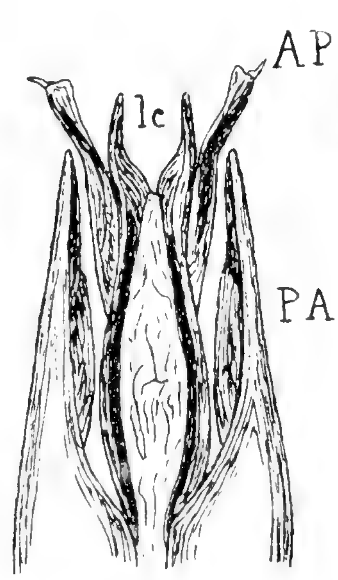


Fig. 8.
N. politus Casteln.
Extremity of aedeagus. Ventral view.

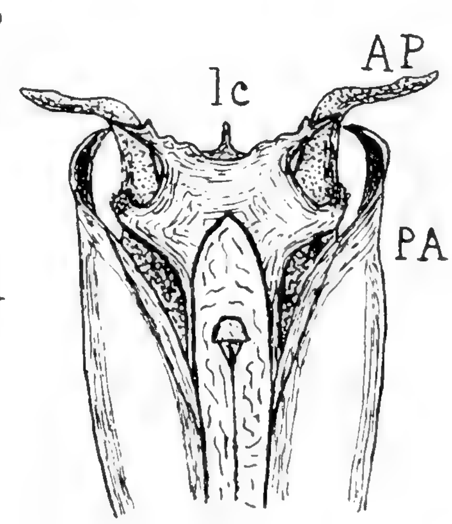


Fig. 9.
N. castus Say.
Ventral view of aedeagus.

N. politus seems rather closely related to *grandis* Casteln. Finally I draw attention to the very peculiar shape of the aedeagus in *N. castus* Say (text-fig. 9), the seventh American species known to me.

The other names, *obtusatus* Leconte (nec Say), *tenebrioides* Jacq.-Duv. and *perfectus* Sharp seem to be synonyms of *castus* Say. Still another name, *N. irinus* Brullé, 1838, exists, but it applies to a single Argentinian female, very insufficiently characterised and which I have not seen (Museum of Paris). *N. irinus* is perhaps not specifically distinct from *N. medius*?

The components of the genus *Neohydrophilus* are of so great a uniformity that the usually mentioned characters — as f. i. the length of pro-and metasternal spines — are subject to variation even in individuals belonging to the same species and, worse, they are not always very evident. On the other hand, so far as observation goes, the morphology of the male apparatus offers constant and conspicuous differences which one cannot consider otherwise than as being of specific value The systematic position of the American forms, from a phylogenetic point of view, seems to me the following:

grandis Casteln. (Brazil)
medius Brullé (Argentine, Brazil, ?Bolivia)
phallicus m.*) (Venezuela, Haiti, S. Domingo, Porto-Rico, Guadelupa, Martinica).
ignoratus m.*) (Brazil).
longus Bruch (Argentina)
politus Casteln. (Venezuela, Guyana)
castus Say (Louisiana, Florida, Panama, Mexico, Guatemala, Cuba).

The distribution of *Neohydrophilus* extends from the Philippines, Borneo, Java, Sumatra, over tropical Asia and tropical Africa to South America and, from here, to the Southern parts of North America. As pointed out in 1911, this distribution covers a great part of the hypothetical Australo-Brazilian continent of old geological age called now by Metcalf Equatoria.**) Of course, it is not the place here to enter upon the questions as to whether the roads of migration and evolution of *Neohydrophilus* ran over intercontinental connections or so called bridges, or if such bridges had much less importance than is usually thought, or whether we must accept Wegener's theory of floating continents. But on account of their lateral lobes still articulated with the basal piece by means of a connective membrane, the African *Neohydrophilus* seem to me more primitive than the American components of the genus. The way of introduction of the genus into America is to be searched somewhere on the East coast of Brazil. Here we find the primitive *N. grandis* Casteln. Also *medius* Brullé stands phylogenetically deeper than other American species. I will show here in a diagram the directions of migration of two different groups of species. I would call attention to the fact that the new *N. phal-*

*) For diagnoses of the new species see: Ann. & Bull. Soc. Belg. LXVIII, 1928, pp. 160—166.

**) M. M. Metcalf, The opalinid ciliate Infusorians, U. S. National Museum, Bulletin 120, 1923, p. 306 and fig. 232.

licus, according to the material studied, does not pass from Haiti to Cuba and that *castus* on the contrary is not known from Haiti, but from Cuba. It looks as if a land connection between these two islands did not exist when the primitive stock *phallicus-castus* evolved as two different species, there being an insurmontable barrier to the mixing of the products of evolution. Prof. Lameere has told me that he has observed the same particularity in the distribution of *Prionidae* on Cuba and Haiti, and also migrating directions from Africa to Brazil. I could not find out if Jacquelin-Duval's type of *Hydrous tenebrioides* still exists: all my inquiries were without result. On the other Hand Régimbart's determinations are all erroneous. But as this species was described from Cuba, probably from a single individual, I am inclined to think that Duval's name is merely a synonym of *castus*. I must add that I have seen but a single specimen from Cuba, fortunately a male, and that it belongs to *castus*.

Diagram I.

Directions of distribution of some *Neohydrophilus* (N. *grandis* Casteln. towards the South: N. *longus* Bruch; towards the North: N. *politus* Casteln.).

Venezuela
|
Guyana
|
Brazil (Petropolis)] *politus*

↑

Brazil (São Paulo)] *grandis* ← Africa

↓

Argentina (Santa Fé)] *longus*

Diagram II.

Directions of distribution of some *Neohydrophilus* (*N. medius* Brullé, *N. phallicus* m. and the very isoleted *N. castus* Say).

castus [Mexico, Louisiana, Florida, Cuba, Guatemala, Panama

↑

Haiti, San Domingo, Porto Rico, Guadelupa, Martinica, Venezuela] *phallicus*

↑

? Bolivia, Brazil, Argentina] *medius* ← Africa

Can we Increase the Usefulness of the Egg Parasite Trichogramma minutum Riley?

W. E. Hinds, Ph. D., Entomologist, and
Herbert Spencer, Ph. D., Assistant Entomologist,
Louisiana Experiment Station, Baton Rouge, Louisiana.

Introduction.

For more than half a century this tiny wasp has been recognized as one of our most beneficial parasitic species. The evidence as to its value has been accumulating steadily in our literature on economic entomology as its attack has been recorded upon more than one hundred and fifty host species, mainly Lepidoptera. Reports of its distribution have come from all parts of the United States, Canada, the West Indies, Mexico and several countries in South America, as well as from Europe, New Zealand, Java and Hawaii at least. It appears to be, therefore, of practically worldwide distribution, through sub-tropical and tropical regions particulary. It seems probable that its occurrence in the colder regions where real winters prevail may be due to spread during the summer season from the warmer regions where the species is more likely to hibernate successfully.

In the brief time available our discussion of this insect must be restricted quite closely to our own observations upon it and our efforts to increase its usefulness as an egg parasite upon the sugarcane moth borer, *Diatraea saccharalis* Fabr. At the present time we find *Trichogramma* to be the most important natural enemy of the sugarcane borer in Louisiana.The field observations upon its activity and distribution suggested the possibility of increasing its effectiveness by means of artificial or laboratory propagation upon some favorable host species and field colonization upon the eggs of the sugarcane borer at such time as might seem favorable to its successful and continuous development thereon. It seemed reasonable to assume that if the attack of this parasite on cane borer eggs in the fields could be started at an earlier date in the season, or more abundantly at the same date, there might result a higher percentage of parasitism by the *Trichogramma* and that this higher percentage might possibly be maintained throughout the season with decidedly beneficial effects so far as control of the borer is concerned.

Previous Records on Cane Borer Eggs in Louisiana.

Probably the earliest investigation of the sugarcane borer by a trained Entomologist was conducted by Professor H. A. Morgan, Entomologist of the Louisiana Experiment Station from 1889 to 1905. In his first publi-

cation dealing with the borer, Louisiana Bulletin No. 9, Second Series, 1891, Professor Morgan makes no mention whatever of *Trichogramma*, although he recorded the beneficial work which was being done by the predaceous larvae of a soldier beetle which fed upon the borer larvae. Again in 1897, in speaking of the enemies of the cane borer, he mentioned specifically the soldier beetle larvae and ants, but had not observed the *Trichogramma*. Even as late as 1902, in Louisiana Bulletin No. 70, Professor Morgan states: "No true parasite of the eggs or the caterpillars of the sugarcane borer moth were found during the entire period of the investigation".

That *Trichogramma minutum* occurred throughout the South long before the period referred to above is shown clearly by the records of many observers. In 1878, Professor J. H. Comstock found it destroying the eggs of the cotton leaf worm, *Alabama argillacea*, near Selma, Alabama. Furthermore, Dr. C. V. Riley states "We found it quite common (on eggs of *Alabama argillacea*) in Mississippi, Alabama and Georgia, fully one-fifth of the eggs in some fields being infested". Mr. E. A. Schwarz found it rather rare in Texas, while Mr. H. G. Hubbard reported it as very abundant in Florida. Here it was working especially on the eggs of *Alabama argillacea* and of *Heliothis obsoleta*. In the Fourth Report of the U. S. Entomological Commission, in discussing the parasites of the cotton leaf worm, it is shown that the percentage of eggs parasitized increased rapidly as the season advanced, until by August and September from 90 % to 97 % of the leaf worm eggs were destroyed by these parasites.

The foregoing records are useful to us particularly because they give a background for our own ideas regarding the long established usefulness of this very beneficial species. There is every probability that its attack upon the cane borer eggs is not a recently developed habit. Undoubtedly it has been parasitizing cane borer eggs ever since this insect became common in Louisiana, but it would appear that this fact escaped earlier observation simply because of the very minute size of the wasp, which is but rarely seen as an adult in the field.

More Recent Field Observations.

In the more intensive and prolonged study of he cane borer which has been conducted by the U. S. Bureau of Entomology since 1911 under the direction of Mr. T. E. Holloway, *Trichogramma* was found to be generally established and extremely important as a parasite of the cane borer. In U. S. D. A. Bulletin No. 746, published in 1919, Mr. Holloway states (p. 39): "The Chalcis-fly, *Trichogramma minutum* Riley, is universally distributed in the sugarcane fields of Louisiana and of the Rio Grande Valley of Texas and is a very important factor in the control of the moth borer".

Our own study of the cane borer problem began in the summer of 1925 and at that time, during the months of August and September particularly, from 80% to 90% of the borer eggs were being destroyed. However, in spite of this highly effective parasitization, the cane borers were extremely injurious in 1925 and in some small areas they accomplished practically complete destruction of the sugarcane crop. The *Trichogramma* was so numerous

during the fall that we anticipated an abundant survival of the winter and a high degree of borer control the following season.

To our surprise, no *Trichogramma* could be found on borer eggs in 1926 until August, although they were found breeding in the eggs of some other hosts several weeks earlier. In one of these hosts having very large eggs (probably *Protoparce sexta)* more than 75% of the eggs were parasitized and an average of over twenty parasites per egg was produced. This was during the latter part of June and, at that time, no parasitized cane borer eggs could be found. However, by the last week of August, 1926, when cane borer eggs had become much more common, approximately 25% were parasitized and by the first week of November 82% were destroyed. These observations were largely responsible for suggesting to us the possibility of securing by Laboratory Propagation an earlier attack of the *Trichogramma* on *Diatraea.*

Laboratory Breeding begun in Louisiana.

While many Entomologist have studied *Trichogramma* rather closely, the credit for the first large-scale Laboratory breeding of the species of which we are aware belongs to Mr. Stanley E. Flanders, Entomologist of the Saticoy Walnut Growers' Association, Saticoy, California. He has been endeavoring to utilize *Trichogramma* more largely in the control of the Codling Moth on the English walnuts. Our own Laboratory breeding work was started on March 9, 1927. The eggs of the Angumois grain moth, *Sitotroga cerealella,* were chosen as the most favorable and easily handled host which might be expected to supply an abundance of eggs throughout the entire season. This expectation has been completely fulfilled, and the breeding work has progressed very satisfactorily. Improvements in technique have been made from time to time and ideas exchanged freely with other investigators.

In the fall of 1927 special Moth Rearing Rooms were constructed to facilitate much more extensive breeding work. These two rooms were each 12×16 feet with the ceiling about 7 feet high. The stock of corn is kept in trays holding about one bushel each so that they may be easily handled if necessary. The trays are arranged in stacks from the floor to near the ceiling with a clear opening between trays. These trays may be arranged in a double stack extending through the middle of the room and so that the collection of moths may be conducted on the outside walls and ceiling, or the trays may be stecked against the side walls and there will still be sufficient wall space for the collection of moths. The corn is thoroughly fumigated with carbon disulphid before being placed in the Moth Breeding Room completely to destroy all insect life and allow the subsequent introduction of the eggs of the host species desired. In stocking corn with grain moth eggs, it is advisable to introduce as large a number of eggs as possible on each day during the first four or five weeks, so that the supply of moths and eggs produced therefrom may be continuous.

The collection of moths is accomplished by means of an air suction apparatus devised by members of our Staff. This utilizes the suction from an ordinary suction sweeper, but separates the moths from the air current at an intermediate point on the suction line, so that they do not pass into the

fan but are deposited in an ordinary quart glass preserving jar. In this way thousands of moths may be collected in a very short time and without injury to the moths.

In another room and at a considerable distance from the moth rearing work, the handling of the moths for securing their eggs and the exposure of eggs to parasitization by *Trichogramma* is conducted. The moths are divided into smaller lots of from 200 to 300 per quart jar. A disc of smooth letter paper is used under the cover to keep the eggs where they can be most easily recovered, and they are deposited loosely in the jar and on this paper disc. The jars are kept preferably at a uniform temperature of from 80 to 85° F, as this appears to be most favorable for oviposition. After twenty-four hours the jars are gone over, the eggs brushed loose by a soft brush and separated from the moths by covering the mouth of the jar with a 20-mesh brass wire screen and shaking the jar vigorously over a large sheet of smooth paper. From this paper the egg collection is easily transferred into a petri dish, where the eggs may be cleaned by shaking the dish carefully and in a slightly inclined position while blowing gently across it. The cleaned eggs are then distributed on about 4-inch discs of white cardboard which have been prepared by giving them a thin coat of Cico library paste. Eggs are scattered over this paste before it dries and allowed to remain as thickly as they will adhere. When dry all loose eggs are detached by inverting the card and striking it sharply on the back with a pencil. Each card is given a consecutive number and a permanent record shows the date that the eggs were deposited, the date exposed to parasitization, the date parasites emerged, etc.

Under controlled temperature conditions the developmental periods of the moths and of the parasites may be known quite accurately, and it is possible, therefore, to tell within a few hours the time when parasites will be due to emerge from parasitized borer eggs. The transfer of the *Trichogramma* to unparasitized eggs is accomplished very conveniently in petri dishes which are carefully selected for straight sides and close fitting. A piece of plain white paper is placed in the larger part of the dish and this is always used as the under portion. Part of a parasitized sheet from which parasites will soon emerge is placed in the bottom, and above this a full sheet of unparasitized, freshly laid moth eggs. The cover of the dish is then put in place and the whole clamped together by a rubber band. These dishes are then placed in a horizontal position in strong light, but not in direct sunlight. As the parasites emerge in these cages, they soon mate and the females proceed to lay their eggs in the abundant supply of moth eggs which they find so near. In this way it is easily possible to handle from 40,000 to 50,000 moth eggs on one sheet and to secure from 20,000 to 30,000 parasites therefrom.

Under common summer temperature conditions a generation of *Trichogramma* may be produced in from seven to ten days. The life period of the adult is usually only two or three days, and from twenty to forty eggs per female seems to be about the average number deposited. Eggs may be deposited readily by an unmated female. These always produce males and the developmental period appears to be the same as with fertilized eggs. We have not found that the supply of moisture or sweetened water in the petri dish breeding cages adds appreciably to the length of life of the wasps or the

number of eggs deposited by them. An excess of moisture in the cages may interfere seriously with the work.

Temperature appears to be the most important factor affecting the activity and development of *Trichogramma.* The optimum conditions appear to be found between 80° and 90° F. In the field the wasps do not seem to be active during the hottest period of very bright sunny days, but remain quietly at rest on the undersides of leaves. The developmental period may be greatly extended during cool weather, and field tests conducted in January to March, 1928, gave a developmental period of forty-two days and an adult life period with a maximum of fourteen days. During this period, minimum temperature fell to 26° on one occasion and was below 32° F on at least eight dates. Maximum temperatures rose frequently to above 75° F, but not above 80°. These observations may have some bearing upon the solution of the problem as to where and how *Trichogramma* passes the winter.

Field Colonization Tests.

Field colonization work was begun in June, 1927, and during this month some 94,000 *Trichogramma* were released in a field of sugarcane near Baton Rouge where the borer infestation was becoming quite severe. The *Trichogramma* became established immediately and recoveries were frequent within two weeks after the first were liberated. Of course, careful examinations had been made through this and nearby fields before colonization was begun. These examinations failed to show any natural *Trichogramma* infestation present in this area until two weeks after recoveries became common in the colonized fields. Fields of corn and cane quite heavily infested with borers but with no sign of *Trichogramma* parasitism could be found until after the 12th of July. The percentage of borer eggs parasitized in the colonized field was continuously higher throughout the season than in the check field or the average of all uncolonized fields. This is shown in the following table:

Table 1. *Trichogramma* Colonization Experiment, Cinclare, Louisiana, 1927.

	Percentages of Egg Parasitism	
	Colonized Field*)	Check Field
June 9 . . .	0	0
June 23 . .	2.4	0
July 6 . . .	6.9	1.4
July 16 . . .	16.4	9.9
Sept. 20 . . .	97.7	86.8 **)

Field Colonization Work in 1928

During the fall of 1927 *Trichogramma* became extremely abundant and was very effective in reducing the fall generations of borers. Largely

*) Between June 9 and July 14 some 94,000 *Trichogramma* were liberated in this field. These records are based on the examination of more than 111,000 borer eggs.

**) This percentage is the average found in uncolonized fields in this vicinity during August, September and October. Unquestionably during this period many parasites had spread from the colonized to check fields.

as a result of the activity of the parasite the borer population entering hibernation was decidedly smaller in 1927 than it was in 1926.

Climatic conditions through the winter of 1927 to 1928 appear to have been rather unfavorable for borer survival. The minimum temperature of 17° F was experienced during the first week of January and a cool late spring prolonged the hibernation period with a consequent decrease in borer survival. As a result of all factors, the borer infestation through the first half of the season of 1928 has been extremely light, and this condition has handicapped the conduct of *Trichogramma* field colonization.

From all evidence available at this time, we believe that *Trichogramma* does not survive the winter at all in the vicinity of Baton Rouge, unless it be during extremely mild winters. However, there are strong indications that it does hibernate succcessfully close to the Gulf Coast and probably through the process of retarded development in the eggs of some host which provides a continuous food supply for the parasites as they may require it. It appears that the species then spreads northward with the prevailing air movement during the summer. At least, such an assumption would seem to agree with, and may possibly explain, the finding of the first specimens of *Trichogramma* in the field at Franklin, Louisiana, as early as March 25, 1927, and their first appearance at Baton Rouge about the middle of June and at more northern points at correspondingly later dates through the summer.

Our field colonization work for 1928, with the larger supply of parasites available, was planned to include colonizations on the borer eggs as deposited for the first, second and third generations. Accordingly, field colonizations were started on April 19, which was as soon as borer eggs could be found in the fields. Subsequent examinations indicated that few, if any, of these early releases resulted in real establishment of *Trichogramma.* The scarcity of borer eggs, especially between the first and second generations, appeared to have cut off the parasite development by the absence of the necessary continuous host supply.

Colonizations made during the latter part of May and through June for the second generation were uniformly successful in establishing a continuing *Trichogramma* parasitization. Recoveries became common within two weeks and the percentage of parasitization has been increasing steadily and to a very encouraging extent. It is too early in the season to draw any final conclusions from this work. Naturally, the development of parasites occurs first in the vicinity of the liberation points and spreads to adjacent cuts of fields as their multiplication increases. In one field at Baton Rouge where 94,000 *Trichogramma* were liberated between June 7 and 23, 1928, the percentage of borer eggs parasitized was found to be above 35% during the last week of July. Natural parasitism in uncolonized areas in the vicinity of Baton Rouge began to be found about the middle of July.

On the southern edge of the Cane natural *Trichogramma* parasitization was found to be quite heavy among borer eggs on garden corn at Centerville on July 5, but was not found at that time in field examinations of cane and corn. However, in colonized areas where 10,000 *Trichogramma* were released on May 17 in a cane field, 23.6% of the borer eggs were found parasitized on July 5. Examination of two check fields in this locality showed no natural parasitism whatever on this date.

A brief summary of the 1928 results as available to July 31 is given in the followng table:

Table 2. *Trichogramma* Field Colonizations, 1928.

Location (Town)	Colonized		Borer eggs collected			Percentage parasitized	
	Date	No. Tri.	Date	Colonized Field	Check Field	Colonized Field	Check Field
Berwick . . .	5/17	10,000	7/5	352	120	23.6	0
		—	7/27	175	361	52.0	5.8
Franklin . . .	5/29	10,000	7/28	1129	44	33.2	0
Napoleonville	6/21	10,000	7/31	218	—	50.0	—
Sugar Station	6/7	—	6/29	523	128	5.1	0
Baton Rouge (Cut 12)	6/23	94,000	8/3	516	100	12.7	0
Sugar Station	6/7	—	7/2	561	12	14.9	0
Cut 13) . . .	6/23	94,000	8/3	91	157	35.2	0

Even a casual study of the figures given in Table 2 will show clearly that there has been a very successful establishment of *Trichogramma* upon borer eggs of the second generation and that the percentage of borer eggs parasitized in these areas has increased very rapidly during the month of July, while practically no natural parasitism has occurred in the check fields during this period. It seems but reasonable to expect that this advantage in colonized fields will be maintained throughout the season or until maximum parasitization is attained and that this condition will be reached first in the colonized areas.

Final conclusions as to the value of this work must be based upon the records of several seasons and will be shown principally in comparisons of the percentage of bored joints in the stalks of cane at harvest time in colonized as compared with uncolonized areas.

The practicability of large-scale Laboratory production of *Trichogramma* has been fully demonstrated. It has been shown that the sheets of parasitized eggs may be mailed to any part of the United States or Canada with fair prospect of their arriving in good condition. It will require some time to determine whether this work will produce sufficiently beneficial results in the control of insect pests to justify undertaking such breeding work upon a very extensive commercial basis. Our work of rearing moths and parasites has thus far demanded practically the full time of one man, and we are greatly indebted to Mr. C. O. Hopkins, Assistant in Entomology, for his very faithful and efficient handling of this work. On account of the short life cycle of *Trichogramma* only a small fraction of the total number bred during a season can be utilized in field colonizations. Still we feel that the results of the work thus far indicate that it is possible to increase the usefulness of a native parasite such as *Trichogramma minutum* by some such method of assisting them in their survival of the winter and in field distribution.

Mississippi Methods of Enforcing Quarantines against Cotton Pests.

Professor R. W. Harned, A. & M. College, Mississippi.

The appearance of the pink bollworm in the United States in 1917 awakened the people of Mississippi to the danger that threatened the one crop that was worth many times in value all other crops produced on the farms of the State. Only twenty years had passed since the boll weevil had made its first appearance in Mississsippi. Most of the cotton growers had suffered severely from this pest and many realized that the introduction of another major cotton pest might easily destroy the entire cotton industry. There was a general and urgent demand that every reasonable precaution be taken to prevent the introduction into Mississippi of the pink bollworm.

The Legislature that convened in January, 1918, enacted a law known as The Plant Act of 1918, creating the State Plant Board. This act was modeled largely after the Florida Plant Act that had been in force for several years. It gave the Plant Board almost unlimited authority in adopting measures and enforcing quarantines for the protection of Mississippi crops from the introduction of serious insect pests and plant diseases.

At the first meeting of this Board a pink bollworm quarantine regulation was adopted. This rule has been modified several times, but the principle of requiring permits showing the origin and destination of every shipment of cotton seed and seed cotton entering Mississippi has been rigidly adhered to since March, 1920. In 1926, in order to conform with Federal regulations, it become necessary to repeal our pink bollworm quarantine, but the system of requiring permits on all shipments of cotton seed was immediately embodied in another regulation covering certain cotton diseases. This rule, which is still in force, is as follows:

"Rule 59: — The movement or shipment into the State of Mississippi of cotton seed from other States is hereby prohibited except when the shipments are accompanied by a permit issued by the State Plant Board of Mississipi.

"Growers or seedsmen who desire to ship cotton seed into Mississippi for planting purposes must file an affidavit showing that less than one per cent of the bolls in the cotton fields from which the seed came were infected with anthracnose and that the cotton was apparently free from wilt.

"Permits will be issued for the movement of cotton seed into this State for crushing purposes when the shipper has furnished the State Plant Board with an affidavit to the effect that the seeds are intended for crushing purposes only and will not be used for planting.

"Before accepting shipments of cotton seed and seed cotton destined for points in Mississippi, transportation agents will see that a permit issued

by the State Plant Board of Mississippi is furnished by the shipper; and the original permit must be attached to the waybill, accompany the waybill to destination and be kept on file at that point by the transportation agent".

During the past eight years approximately 60,000 permits have been issued for shipments of cotton seed varying in size from single sacks to carloads. These permits are issued in triplicate. The original is permanently attached to the waybill and is filed with it by the transportation company. The duplicate is mailed to the State Plant Board on the day of shipment, and the third copy is retained by the shipper. The duplicate permits are filed in the State Plant Board office according to place of origin. In case a serious cotton pest is discovered at any future time in any other State, our files will immediately disclose all shipments of cotton seed and seed cotton that have originated in that State and their destination in Mississippi. This system of requiring permits has already proved its value on a number of occasions.

The railroads and express companies operating in Mississippi have always cooperated heartily. Without this fine cooperation the enforcement of our quarantine regulations would have been very difficult.

Within a few weeks after the quarantine on cotton seed was adopted in 1920 it was discovered that some cotton seed was entering the State through the mails. This caused us to adopt the parcel post inspection service for all cotton seed and many other plants and plant products. This parcel post inspection service has since amply justified its establishment in many ways.

The inspections of parcel post shipments, express shipments in offices and on trains, and examinations of waybills in freight offices are a part of the duties of Inspectors at twenty-two points in Mississippi.

237
259
316
484
708
929
945